THE ENGINEER.

Electrical Mining Machinery.

INTRODUCTION.

THE application of electricity to coal-mining machinery in this country has made great strides during the last few years. Its adoption in our mines came considerably later than was the case either on the Continent or in America; but since the start the progress has been fast. The numbers of collieries in Great Britain which are now making use of electricity is large. Practically the only direction in which this form of power is not employed extensively is in winding and main ventilation. Possibly this may come in time, but at present there are but few plants of either types at work. Ventilation by electrical means has hardly received the attention which we feel will be devoted to it in the near future. Details of an electrically-driven fan installation unfortunately reached us too late for inclusion in this Supplement. They will, however, be found in another part of this issue. With these two exceptions electricity may be said to be widely and increasingly used in all departments of coal mining, in lighting, pumping, hauling, coal cutting, and in working the other multifarious machines and apparatus at bank which go to form the equipment of a modern colliery. It is the purpose of this Supplement to lay before our readers some few details of these various applications of electricity, and to discuss the advantages offered by this form of power.

Twenty years ago it would have been hard to convince a colliery manager that any but the methods he had been brought up to were of any value. Now, however, conditions have altered. Economy is sought for in every direction, and the desire to produce cheaply has in the majority of instances overcome conservatism. Moreover, the younger generation, as it has grown up, has imported modern ideas into the business; so that every ton of coal which can be saved is saved, and seams are now worked to pay which formerly would have been passed over as impracticable by hand methods. To this end the electrically-driven coal cutter has largely contributed, but the result is also due in some measure to all the uses to which electricity is put in the mines, and to the more efficient haulage, pumping, and lighting thereby obtained.

Electricity offers a number of advantages for work in coal mines. Perhaps the chief of these is the ease and economy with which it can be conveyed and utilised to far-off points, and positions to which it would be well nigh impossible to take any other form of power economically. Then, too, it is readily adapted to differing conditions, and by its aid considerable saving in production is obtained. There are drawbacks, without doubt, to its use, but these are as nothing when compared to the advantages to be looked for. Such is evidently the opinion of the members of the Departmental Committee which has been considering the use of electricity in mines, and whose report has recently been issued. One sentence of this report we may quote:—"When, therefore, we reflect upon the mitigation of severe and exhausting labour, and the far greater efficiency that the use of electricity is likely to produce, and which ought to result in benefit to the miner, the consumer, and the coalowner alike, we have no hesitation in saying that this new agent ought to be welcomed." In welcoming it the Committee have drawn up a set of rules and regulations which they suggest shall be adhered to in all mines using electricity.

We have, unfortunately, not got the space to deal with these suggested rules at any length. We may say, however, that the majority are such as will be accepted by users and makers alike as being most beneficial and necessary to the safe use of this form of energy. There are other rules suggested, however, which it is thought by our manufacturers and users—all of whom are most anxious to do everything which may conduce to the safety of the miners—will not only not do good, but may possibly do harm by hampering the industry. However, we understand that the Home-office is being most influentially approached, and we have every reason to hope that the final rules, when issued, will be acceptable to all.

In the early days of electrical engineering there were too few really mechanical engineers who interested themselves in the design and manufacture of electrical plant. This stigma has long been removed, and now electrical machines of all kinds are produced which attain a high state of mechanical perfection. Perhaps in no branch of engineering is strength and endurance more called for than in coal mining. Down a pit machines are constantly being subjected to numberless strains which above ground would only come upon them very exceptionally. All coal-mining machinery should be capable of being pulled up short without damage. A fall of roof or any similar obstruction may suddenly stop a haulage system, for example. Again, in damp mines, trouble may be met with in the form of water. This is a contingency only very remotely possible above ground.

When the use of electricity in coal mines was first mooted, a great deal of stress was laid on the danger from explosion due to sparking, whether from switches, commutators, or faulty mains. From a number of most interesting experiments, carried out by Mr. Wm. Charles Mountain—of Messrs Ernest Scott and Mountain, Limited, of Newcastle—on behalf of the Departmental Committee, with electric motors running in explosive mixtures, it appeared that even with an open-type motor sparking badly the mixture had to reach the strength of 10 to 1 before explosion took place. A mixture of 15 to 1 would not explode. An enclosed motor, on the other hand, ran for three hours in a 10 to 1 mixture, with the brushes specially adjusted to produce sparking, without explosion taking place. Moreover, this same motor in the same condition ran for three-quarters of an hour in a mixture of 8 to 1 without the mixture being exploded. It was also started and stopped several times in rapid succession, again without explosion. The current on these occasions was, of course, considerably in excess of the normal, and there was consequently excessive sparking.

These experiments have been confirmed by others, and it would appear, therefore, that one of the chief reasons for not using electricity is, to a great extent, removed.

With so much preface, we can proceed to describe various types of machines which are now at use in our mines. In doing so we have to acknowledge our indebtedness to the various makers who have provided us with the materials and information which we are now able to lay before our readers. In a case of this kind it is impossible to mention every maker, and because the names of some may be omitted, this by no means signifies that the machines they manufacture are in any way inferior to those which are illustrated.

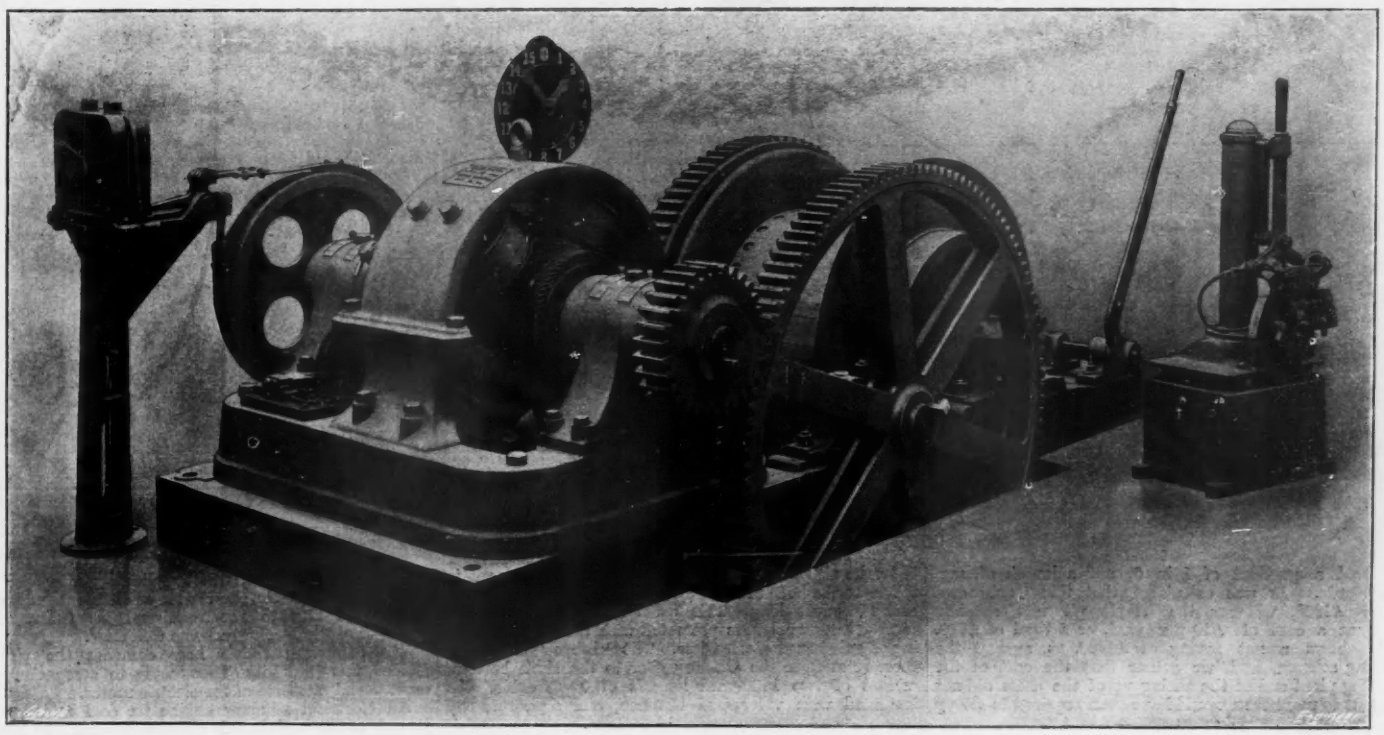


Fig. 1—ELECTRIC WINDING ENGINE

WINDING PLANTS.

Electrical coal winding has not been practised in this country to the same extent as abroad. There is a widespread feeling that it would not pay to discard the excellent steam engines now employed in nearly every instance. Possibly, also, there is a certain distrust of things electrical which remains from early times and prevents the use of electrical machinery in this direction. Be this as it may, the fact remains that only in a very limited number of instances is electric winding resorted to. However, we are enabled to describe one plant, at all events, which has been at work in this country for some time, and has given, so we understand, every

satisfaction. The installation in question is at work in the Victoria Pit of the Heckmondwike Collieries Company, Limited. The seam being worked is called the Low Moor Black Bed. The winding plant became necessary owing to the cropping in of a large "fault" or "throw," about 1000 yards from the pit bottom. Here the seam is thrown down a vertical depth of 60 yards from the original level. In order to get at the lower portion of this seam, it was found necessary either to drive a large inclined drift or to sink a staple pit. Had the drift been decided upon, it would have involved a gradient of 1 in 6, and a length of, say, 360 yards. It was calculated that this would cost some £1960, whereas the staple pit was actually sunk at a cost of £10 per yard, or a total of £600. This shows a net saving of £1360, as against the drifting scheme, and we gather that the cost of the winding plant and of the fitting up of the shaft did not amount to more than would have been required to fit up the drift with a haulage plant. The annual cost of maintenance is in favour of the staple pit, and the cost of handling the coal about the same in each case. The coal was, moreover, won nine months sooner than it would have been had the drift been decided upon. The new shaft is circular, and is 9ft. in diameter inside the walling. It is fitted with two head pulleys 3ft. in diameter, and with two cages, each made to carry one tub, the cages being kept in position by two guides of wire rope ¾in. in diameter. The pit top is fitted with fallers or keps, the whole being arranged exactly as in ordinary cases. The winding gear employed is shown in Fig. 1, page i. It is said to be capable of raising from 150 to 200 tons per day of 10 hours.

On the surface there is a horizontal single-cylinder engine, the cylinder being 16in. diameter by 36in. stroke. The steam pressure is 50 lb. per square inch, and the engine runs at 80 revolutions per minute. This engine drives a continuous-current compound-wound four-pole dynamo of 30,000 watts capacity, and capable of giving 500 volts at 850 revolutions per minute. The current is taken to the bottom shaft by two lengths of 19/17 cable, each 230 yards long. This cable is insulated with vulcanised bitumen, and is protected with a double armouring of galvanised steel wires. The "inbye" cables, or those running to the winding gear to the shaft bottom, consist of two 1000-yard lengths of 19/17 cable, also insulated with vulcanised bitumen, and supported by insulators along the road. The winding gear consists of a drum, 3ft. in diameter, driven by a four-pole motor through two sets of reduction gearing, the ratio of reduction being about 15½ to 1. At the ordinary speed of winding, the 60 yards of rope are wound up in from 40 to 45 secs. The motor is series-wound, and is designed to work up to 40 effective horse-power at a speed of 500 revolutions per minute. The armature is of the slotted drum type, with former-wound embedded coils. The first motion gearing is machine cut forged steel, and the second is machine-moulded cast iron. There are two brakes—one of the ordinary band type, and the other, which may be seen at the left-hand side of the engraving, is worked electrically, and it comes into action immediately the current ceases to flow. It is, so we gather, strong enough to sustain the load, so that no danger should ensue from an accidental breaking of the circuit. An indicator, worked off the gear, is provided, and the whole is operated by means of a liquid controlling switch, arranged for reversing and speed regulation. The whole of this interesting installation was supplied by Messrs. Ernest Scott and Mountain, and was carried out under the supervision and to the requirements of Mr. Parkin, manager of the Heckmondwike Collieries.

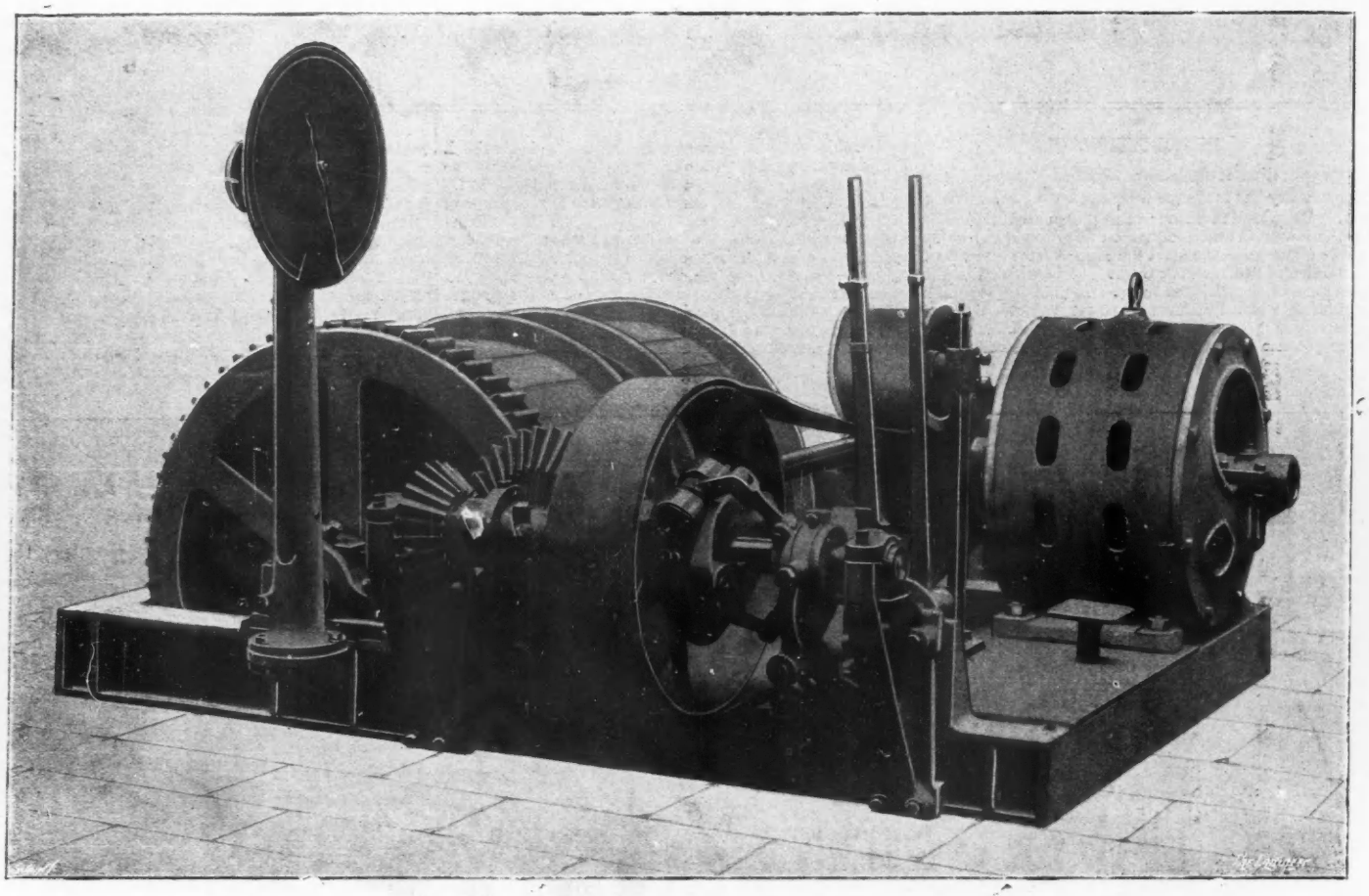


Fig. 2—ELECTRIC WINDING ENGINE

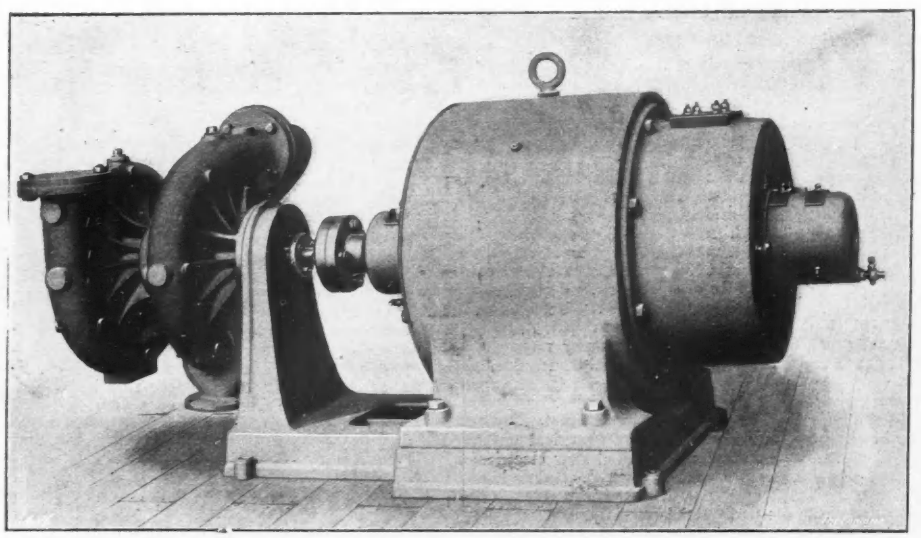


Fig. 3—ELECTRICALLY DRIVEN CENTRIFUGAL PUMPS

The engraving shows how compact the plant is. Indeed, this capability of conducing to compactness is a most useful attribute of the electric motor.

An electrical winding engine for coal mines, which, though not at work in this country, was made by a British firm—Messrs. Mather and Platt—and is working in a British Colony, is shown in Fig. 2, above. This machine is, as will be seen, provided with two drums, as it was supplied to be used in sinking as well as for winding. The right-hand drum is loose on its shaft, but can be thrown into gear with the other by means of a claw clutch at the right-hand side of the machine—this clutch cannot be seen in the engraving. The winding drums are each 4ft. in diameter, and the total work with which the machine has been designed to deal is the lifting of one ton at the rate of 600ft. a minute, or a speed of the drum of nearly 50 revolutions a minute. A glance at the engraving will serve to show how the machine is worked. The motor drives by a belt on to a countershaft. An adjustable jockey pulley presses on the top of the belt and keeps it tight, this being necessary owing to the shortness of the drive. The pulley runs free on the countershaft, but the latter can be made to revolve with the pulley by means of a Mather and Platt friction clutch, which we describe in another part of this Supplement. This clutch is actuated by a signal lever. The countershaft has keyed to it two bevel wheels, either of which can be made to revolve by a double crown clutch worked by the other signal lever on the driving platform. These bevel wheels engage with a third bevel wheel on a cross shaft which carries a toothed pinion; this in its turn engages with the toothed wheel on the drum shaft. From the end of the shaft is taken a small extension spindle which is provided with a worm. This worm works into a worm wheel fixed at the lower end of the vertical spindle of a revolution indicator, just as in ordinary colliery winding practice. The base plate of the machine is made up of cast iron girders subdivided for easy transport, and to enable the various portions to be more readily lowered down a shaft. The motor illustrated is of the two-phase induction type, with a short-circuited rotor. It is said to be capable of giving out 40 brake horse-power when running at a speed of 750 revolutions per minute. The motors can be started "light," thereby doing away with complicated switch gear. On starting, the friction clutch is out of gear, and all that the motor has to do is to turn the belt and the loose pulley on the countershaft. The double crown

clutch is then thrown to whichever side it is desired, the friction clutch is gradually closed, and the motor takes up the load. Starting and stopping is brought about by means of a switch worked by foot from the driving platform, and the whole may be termed a workmanlike and compact piece of engineering design.

PUMPING PLANTS.

Messrs. Ernest Scott and Mountain possess the great advantage as manufacturers of electrical mining machinery in being also makers of the engines to drive the generators, and of the various gears and appliances which are driven by the motors. Thus they are makers of hauling and winding gears, and also of pumps. We have seen a number of each type both at rest and in motion, and we propose to give descriptions of several of each. In the larger sizes of pumps this firm prefers rope driving for transmitting the power of the motors to the pumps. For the smaller sizes, however, gearing is employed. The first pump which we propose to describe, and which has been specially designed for driving by ropes from an electric motor, is shown in Fig. 4 below. It is installed at the Dean and Chapter Colliery, near Ferryhill in Durham, belonging to Messrs. Bolckow, Vaughan, and Co., Limited. It is driven by a three-phase induction type motor of 100 horse-power and 500 volts per phase. The periodicity is 50, and it runs at 580 revolutions per minute. The motor is fitted with slip rings for starting, and is provided with a lever which short-circuits the rotor, and raises the brushes when full speed is reached. It drives the pumps by means of six 1¼in diameter cotton ropes. The pump is of the three-cylinder horizontal type, the crank axle being driven from both ends by means of a cross shaft and gearing, this being a special feature in all Messrs. Scott and Mountain's larger mining pumps. The rams are of gun-metal, and 10in. in diameter, and the stroke is 15in. The number of revolutions is about 42 per minute, and the pump is constructed to deliver 500 gallons per minute under a head of 400ft. Another feature about this firm's pumps is that all the pump barrels, valves, glands, &c., are all interchangeable.

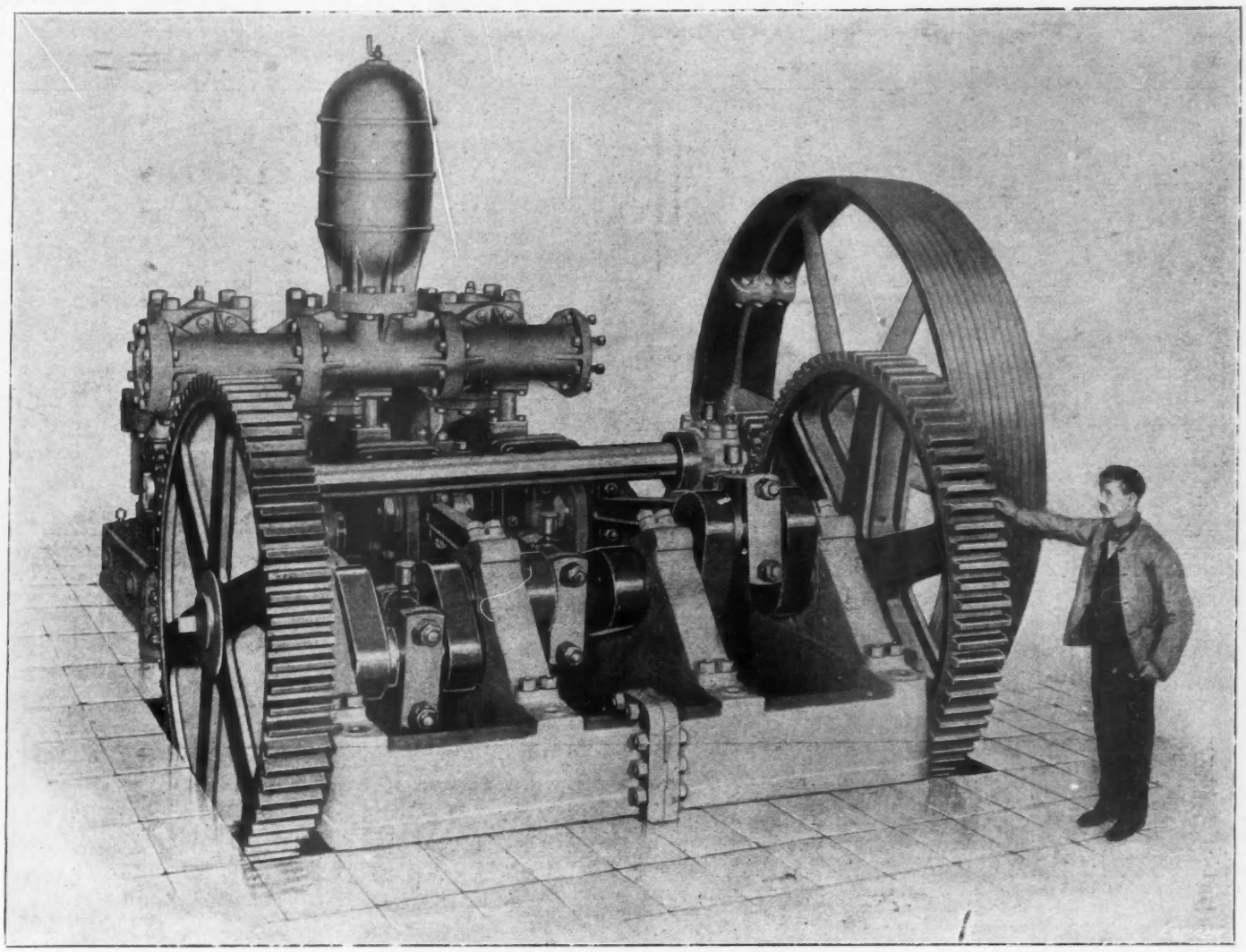


Fig. 4—HORIZONTAL MINING PUMP FOR ELECTRIC DRIVING

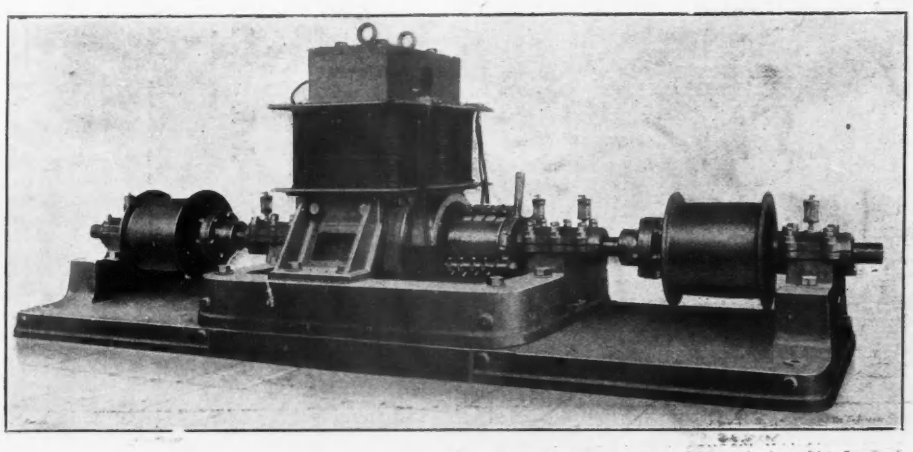


Fig. 5—TWO PULLEY MOTOR FOR MINING PUMPS

At the Broughton and Plas Power Collieries, near Wrexham, Messrs. Ernest Scott and Mountain have installed several electrically-driven pumping plants. One of these is similar in design, though smaller, to the pump just described and shown in Fig. 4 above, only it is belt driven on to pulleys on both sides of a cross shaft. The pump plungers have a diameter of 6in. with a stroke of 12in. They are designed for delivering 150 gallons per minute—9000 gallons per hour —against a head of 800ft. This pump is driven in a somewhat unusual manner by means of the two-pole undertype motor shown in Fig. 5, on this page. It will be seen that this motor, which is of 60 brake horse-power, has four bearings and two flanged pulleys. In a smaller plant than the foregoing, and at the same colliery, the pump has, like the foregoing, three barrels, each 4in. in diameter and 6in. stroke. It is designed to deliver 50 gallons of water per minute against a head of 125ft. It is driven by a 5 horse-power motor. Still another set, also at the Broughton and Plas Power Colliery, is shown

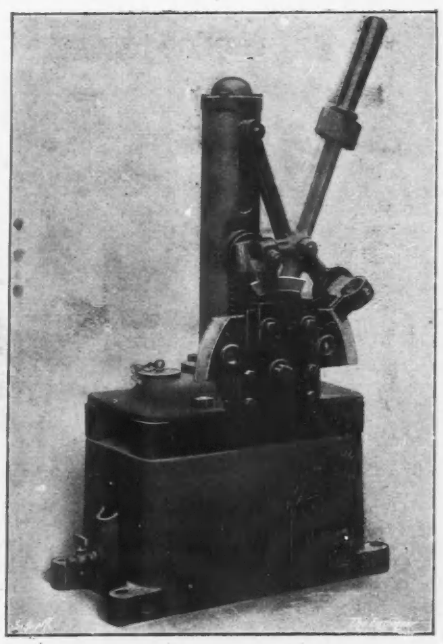


Fig. 6—STARTING AND REVERSING SWITCH

in Fig. 7, below. This is a very compact plant, and is so sub-divided in construction—as, indeed, are all the pumps made by this firm—that there is no difficulty in getting it in pieces down a shaft, no matter how small this may be. This set, again, has three barrels, each 5in. in diameter and having a 7in. stroke. It is capable of delivering 80 gallons per minute against a head of 230ft. when running at, approximately, 55 revolutions per minute. The pump is driven through double reduction gearing by an 11½ brake horse-power motor of Messrs. Scott and Mountain's Class S type. The motor has four poles, and is what is termed self-contained—that is, it has no need of an outside bearing, both bearings being carried in the end covers. It runs at 970 revolutions per minute. In addition to the foregoing, there is another 5 horse-power motor fitted with worm gear reduction for driving a single barrel pump which was previously driven by steam.

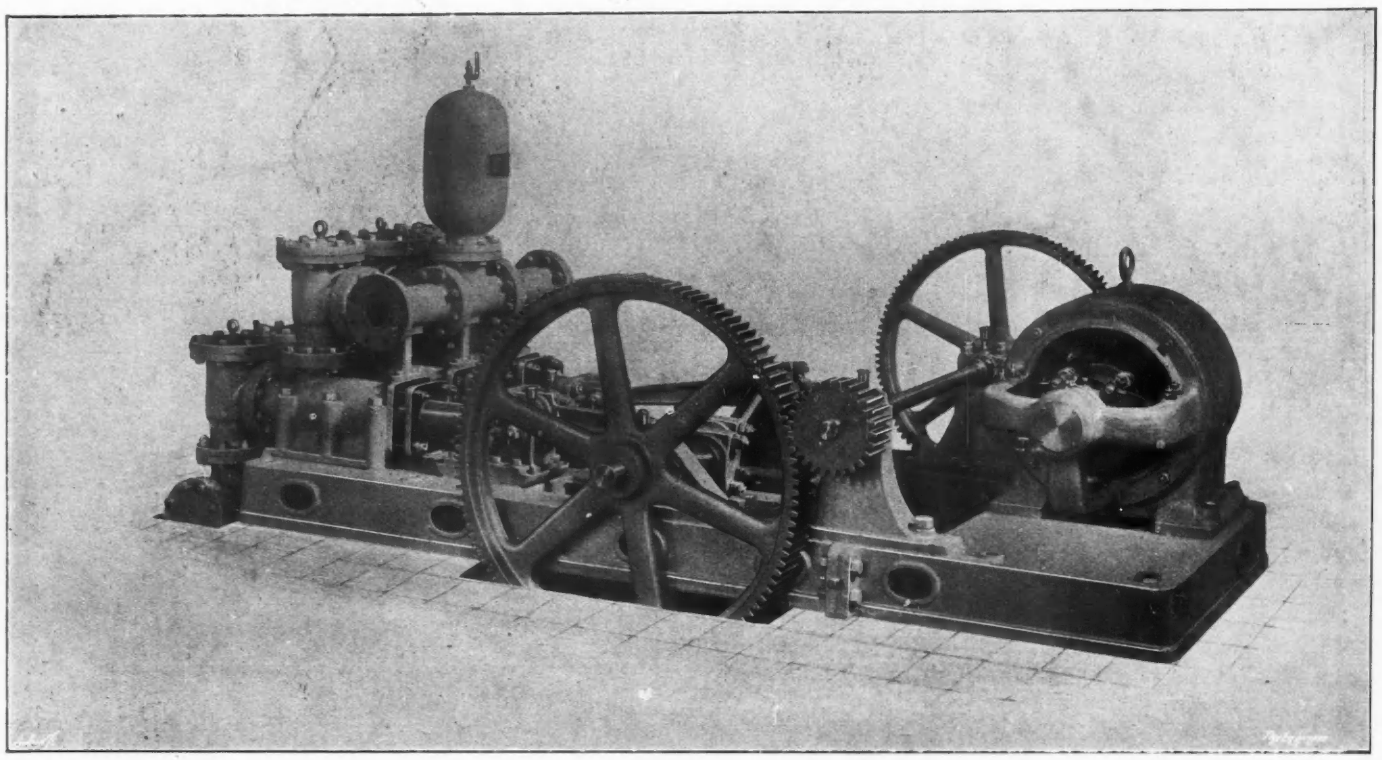


Fig. 7—MOTOR DRIVEN THREE-THROW MINING PUMP

We may, perhaps, mention here, though it is not immediately connected with pumping, with which for the moment we are dealing, that Messrs. Scott and Mountain have installed a large amount of electrical machinery at this colliery. This includes two horizontal compound engines, each of 350 indicated horse-power; two 200-kilowatt compound-wound four-pole generators, rope driven, with a voltage of 580 to 600 at full load; one vertical compound enclosed engine of 330 indicated horse-power driving direct a 200-kilowatt six-pole generator of the same voltage as the foregoing; one 200 brake horse-power motor; two 150 brake horse-power motors; two endless rope haulage gears for operating three roads; the various pumping motors to which we have alluded, and four 7½ horse-power motors, these being employed in driving machinery, including the screens, at bank.

A compact little double centrifugal pumping plant by the same firm is shown in Fig. 3, page ii. This is at work at the Langley Park Colliery of the Consett Iron Company, Limited. The motor, which is of the entirely enclosed type, gives 20 brake horse-power at 950 revolutions per minute. The pump is intended to deliver 200 gallons per minute against a head of 100ft. It is started and stopped by one of the firm's liquid mining switches, one of which, suitable for forward or backward working, is shown in Fig. 6, page iii. This is the type of reversing switch the firm recommends for pumping, haulage gears, &c., in non-fiery mines. It is very similar to the form used in the winding gear at the Heckmondwike Colliery, and shown in Fig. 1, page i. The commutator is in the form of two plates; the large plate is attached to the top of the switch, which is one pole of the circuit; the smaller plate is insulated from this, and has a terminal—not shown in the engraving—connecting it to the other pole of the circuit. The dipper plate is attached to the rod working in the vertical guide. This rod has a piston fitted to it, which is pressed upwards by a spring. If the handle is drawn to one side or the other, it pulls down this piston, depressing the plate into the liquid, and if the handle is let go, it flies back, due to the pressure of the spring, to the off position. There is a small locking catch which can be seen on the top of the connecting link, which holds the handle in the central position. In fiery pits this firm has fitted metallic controllers, with the switches arranged to work in oil.

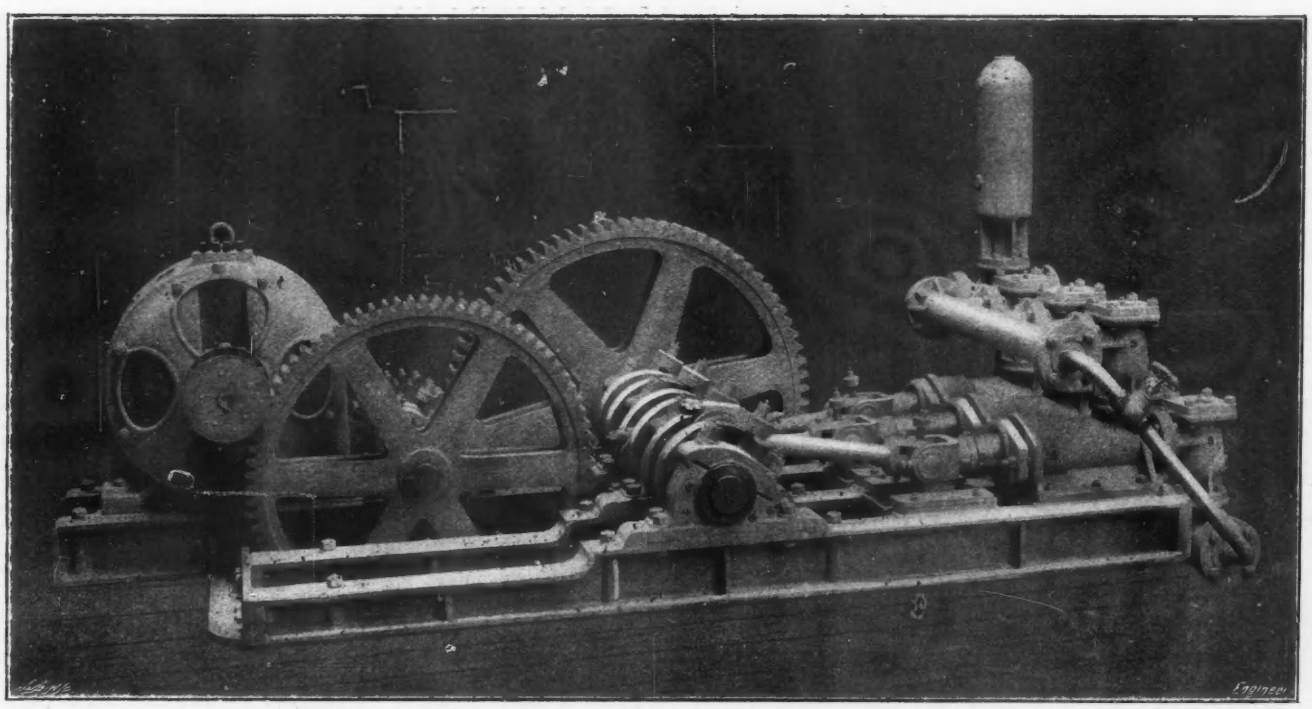


Fig. 8—ELECTRICALLY WORKED HORIZONTAL MINING PUMP

By the courtesy of Messrs. Scott and Mountain, we visited two collieries fitted up by them, and were enabled to observe their methods of installing pumping machinery. Figs. 13 and 14, page vi., give an excellent idea of two underground pumping plants, one of them driven by a direct-current and the other by a three-phase motor. The first of these is at work at the South Durham Colliery Company's pit at Bishop Auckland. The plant is very similar to that at Messrs. Bolckow, Vaughan's Dean and Chapter Colliery, already described. There are two sets, and each is designed to deliver 500 gallons of water per minute against a head of 400ft. The motors are of 120 effective horse-power, and are wound for 450 volts direct current. They are of the four-pole entirely open type, and revolve at

450 revolutions per minute. They drive the pumps by rope, and run at 450 revolutions, the pumps making 28 revolutions per minute. The engraving shows the switchboard and mains, both electric and water. In the engraving, Fig. 14, is shown the underground pump-room at the Ty Tryst Colliery of the Tredegar Iron and Coal Company, Limited. The pumps are identical in form with

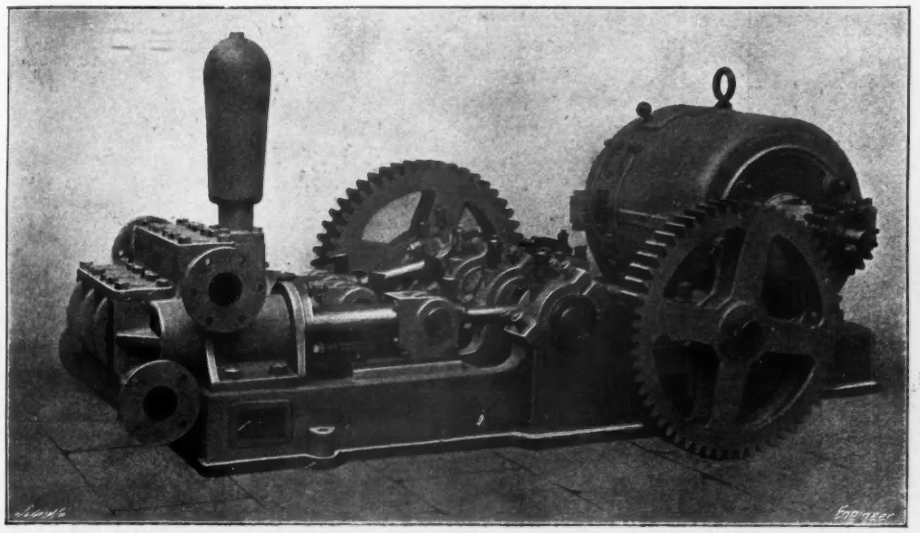


Fig. 9—THREE-CYLINDER ELECTRIC MINING PUMP

that already described, but the plungers are 9in. in diameter with a 15in. stroke, and they make 26 revolutions per minute. They are designed to deliver 250 gallons of water per minute against a head of 650ft. The motor is, as already stated, three-phase, with a periodicity of 40. Its horse-power is 75, and it runs at 590 revolutions per minute. We are informed that its efficiency is 88 per cent., with a power factor of 0·93. Starting switches, volt meters, ammeters, fuses, &c., are provided, and may be seen in the engraving.

At this colliery also this firm has installed a large amount of plant which is of interest because it is three-phase. The main engines are horizontal coupled-compound, and run at a slow speed. They drive the generators by cotton ropes. The pressure of the generators, which are of the revolving field type, is from 500 to 550 volts per phase, and the periodicity 40. Each generator has 14 poles, and gives 290 ampères per phase at 500 volts with a non-inductive load, each having an output of 250 kilo. volt-ampères, and there are three of them. Two pits are equipped, and the current is stepped up to 2000 volts for transmission from the one to the other. Three-core cables insulated with vulcanised fibre and vulcanised bitumen. The main cables are double steel wire armoured. Down the Old Coal Seam shaft, which is 220 yards deep, the cables each weigh 2¼ tons in the shaft. They are fixed on twelve steel girders, 12in. × 6in., spaced at 60ft. centres, and the cable is hung in a double pitch pine cleat, 5ft. long by 10in. square. It is fastened to the joist by 1in. diameter bolts passing through the wood, and having a ¼in. wrought iron plate back and front. Underground the cables have been laid as far as possible in steel semi-tubes filled solid with bitumen compound in all swampy places. The tubing runs at the side of and below the rails of the engine-plane, where risks of damage from falls or wrecked journeys is remote. Rubbish is filled over the tubes throughout their length to an average depth of 15in. All these cables are laid through intake roads. There are several joint boxes in the lines, all of the three-core aggregate output being 445 brake horse-power. Fig. 16, page vi., shows a distributing board at the Old Coal Seam pump-room. It will be seen that there are no marble or slate panels, the switches, &c., being mounted on an angle-iron frame, and insulated by porcelain insulators. The makers inform us that in damp pump-rooms this construction has given excellent results. The Bedwellty Colliery is about a mile from Ty Tryst. Fig. 17, page vi., shows the step-down transformer and low-tension distributing board at the former place, and Fig. 26, page x., one of the starters and controllers used for the haulage

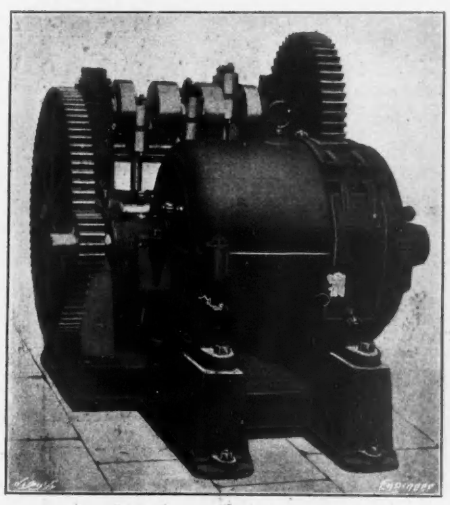


Fig. 11—20-H.P. ELECTRIC MINING PUMP

sweated type. The boxes are accommodated in substantial brick pits constructed in cement, with cast iron covers. One pump is worked at a distance of 1900 yards from the shaft. There are thirteen motors at Ty Tryst, their gears at this colliery, for both pumping and hauling are done there. The whole installation is full of interest.

There is by no means agreement as to whether it is better to use direct or polyphase currents in coal mines. Three-phase current is being extensively used, but it is doubtful if it will ever entirely displace direct current.

Fig. 8, page iv., shows a pumping plant electrically equipped by the Electric Construction Company. The motor is of the three-phase type of 36 brake horse-power. It works at 40 volts and 50 periods per second. It is direct coupled through double reduction gearing to a three-throw horizontal pump, made by Messrs. Joseph Evans and Co., of Wolverhampton. There is a bye-pass on the rising main which allows the motor to be started up against a light load. It will be observed that the bed-plate is subdivided to enable the machine to be easily got down a shaft, and that the whole forms a well-designed and strong construction. The pump has cylinders 12in. by 9ir.

In Figs. 9, 10, 11, and 12, on this page, are given illustrations of a series of pumps, electrically equipped by Messrs. Mavor and Coulson, and especially designed for work in mines. These illustrations very nearly describe themselves, but we may usefully add the following information:—Fig. 9 is intended to deliver 2000 gallons of water per hour against a head of 660ft. The pumps are three-throw, and are connected through double reduction gearing to an enclosed motor bolted to the same bed-plate. The speed of the motor, which is provided with grating covered doors for inspection purposes, is 600 revolutions per minute, and it is of 12 brake horse-power. The pump plungers are 3in. in diameter, and the stroke is 5in. Fig. 10 shows a

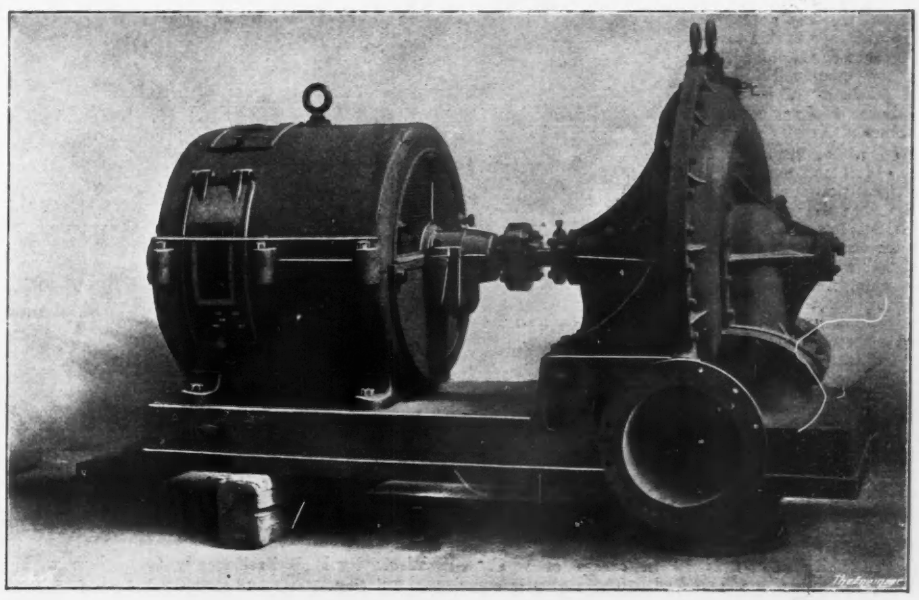


Fig. 10—ELECTRICALLY DRIVEN CENTRIFUGAL MINING PUMP

50 horse-power centrifugal pump, coupled direct on the same bed-plate to an enclosed type motor with gratings for ventilation and inspection. The suction and discharge pipes are, it will be observed, cast in one with the bed-plate. This pump is intended to raise 240,000 gallons of water per hour against a head of 25ft. The speed of the motor is 400 revolutions per minute. Fig. 11 represents a 20 horse-power enclosed type motor, direct coupled on the same bed-plate through double reduction gearing to a set of three-throw vertical plunger pumps. The diameter of the plunger is 4½in., and the stroke 8in. The motor runs at a speed of 500 revolutions per minute, and the combined set was designed to deliver 3000 gallons of water per hour against a head of 900ft. per minute. Fig. 12 represents a much smaller pump than either of the foregoing. It is, as will be seen, a three-throw pump, the cylinders being set at an angle of 120 deg. apart. This dip pump was made to deliver 4200 gallons of water per hour against a head of 120ft., the motor being of 5 horse-power, and running at 300 revolutions per minute. All the motors in the foregoing combined sets were of the firm's standard enclosed mining type, were direct-current machines, and were wound for a voltage of 450.

Another firm which makes engines, pumps, hauling and other gear, besides electric machinery, is Messrs. Mather and Platt. A type of pump which they strongly recommend for work in coal mines is their centrifugal pump. Among the points wherein this pump is claimed to possess special advantages may be mentioned that it has no moving parts in contact saving in its bearings, and that hence wear and tear are at a minimum; that it has no need of air vessels, and since it runs at a high speed it can be designed to occupy a small space; that heavy foundations are unnecessary; and that, owing to the speed of its rotation, the pump can be coupled direct to the spindle of an electric or other motor, thus obviating the necessity of gearing. The feature of this pump is that it consists of one or more sets of vanes or impellers, each running in its own chamber but upon the same shaft. The height to which a given quantity of water can be pumped varies directly with the number of chambers thus used together in series. Axial thrust is eliminated in this pump. The water enters the revolving wheel axially, traverses the curved internal passages between the vanes, and is discharged tangentially at the periphery into a stationary guide ring which conveys it to the annular chamber in the body of the pump, where the velocity is converted into pressure head. The water is nowhere forced to undergo a sudden change of direction

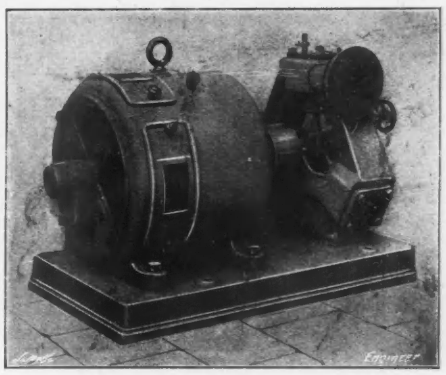


Fig. 12—THREE-CYLINDER ELECTRIC DIP PUMP

or to meet with a sudden difference of cross section in the passages. We have previously referred to the construction of this pump, and there is therefore no need to discuss it further here. We have merely inserted the foregoing to make our description of the engraving—

Fig. 15, below—all the clearer. This illustration represents a four-chambered pump, designed to lift 1000 gallons of water per minute against a total head of 320ft. This represents very nearly 100 horse-power. This pump is coupled direct through a flexible coupling to a 160 brake horse-power three-phase induction motor, working at 220 volts, a periodicity of 50, and a speed of 750 revolutions per minute under normal conditions. The motor has eight poles and a comparatively large diameter. These facts, taken together with the special type of slot used, enable a high power factor to be obtained. There is a 2 mm. clearance between rotor and stator. The actual pump efficiency is said to be 75 per cent. at full load, and the combined full-load efficiency of pump and motor 69·5 per cent. This makes the efficiency of the motor 92·6 per cent. at full load, and it is therefore not surprising to find that the temperature rise is low. No doubt the motor has been thus designed with a view to its working for prolonged periods in positions where the ventilation may be none too good. We understand that the temperature rise after eight hours' continuous run at full load was only 18 deg. Cent. The efficiency of this motor does not fall seriously even when the load is varied 25 per cent. either above or below full load. This motor may be taken as a typical example of the three-phase motor made by Messrs. Mather and Platt, saving that its periodicity of 50 is 10 in excess of what is actually taken as the standard. The stator is composed of soft annular discs clamped in a cast iron frame and stamped with slots for the insulated conductors. The rotor winding is of the drum type, and the ends of the circuits are brought out and attached to slip rings on the axle, on which press the brushes. In the engraving the motor is shown with its liquid starting resistance, which is arranged to short-circuit as soon as the motor has reached its normal speed. We do not quite know whether a limit has been reached to the head obtainable by putting more and more pumps in series; but we understand, at all events, that Messrs. Mather and Platt are prepared to supply pumps of this type to work under a head of 800ft.

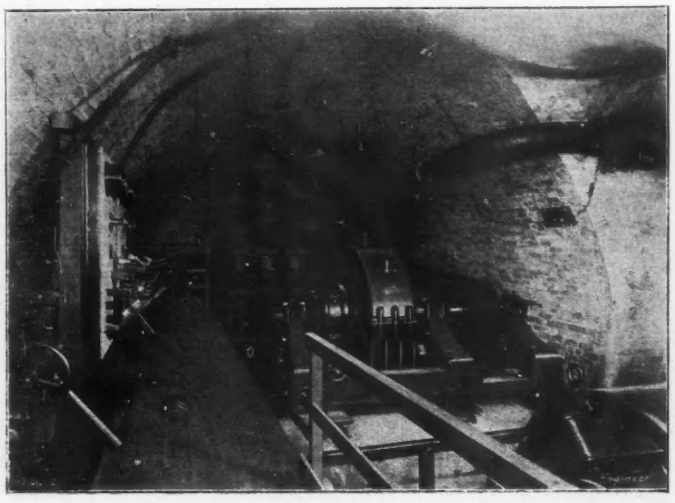


Fig. 13—PUMP ROOM, BISHOP AUCKLAND COLLIERY

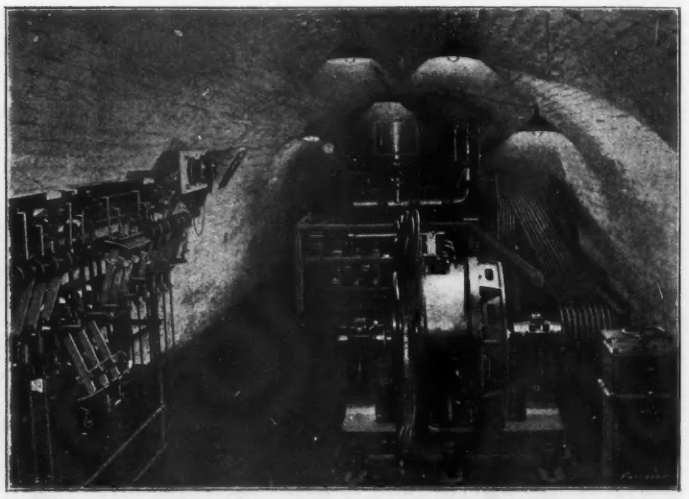


Fig. 14—PUMP ROOM, TY TRYST COLLIERY

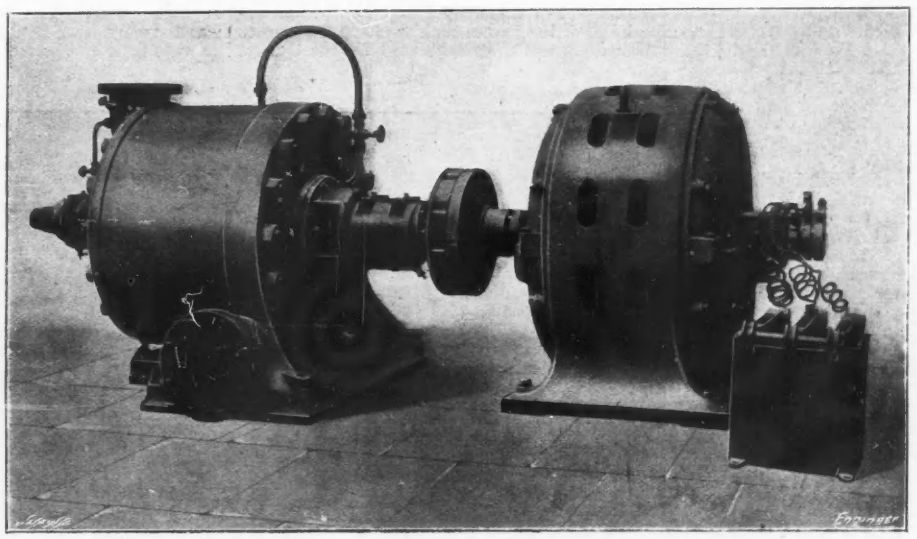


Fig. 15—FOUR-CHAMBER MOTOR DRIVEN CENTRIFUGAL PUMP

HAULING PLANTS.

Electricity lends itself readily to haulage work, and haulage and pumping form the two directions in which electricity is most employed in British coal mines. It would be quite impossible to describe a hundredth part of the numerous electrically-driven plants for either of these purposes, and a short reference to one or two must suffice. It would be invidious to say that this firm or that had done the most work of this kind, and we shall attempt no such thing. Several makers have been courteous enough to place photographs and particulars at our disposal, and we shall now proceed to describe certain installations which appear to us to embody features which are worthy of notice. Messrs. Ernest Scott and Mountain have supplied a large number of haulage gears of different kinds, and their experience in this direction is undoubtedly extensive. We have had the opportunity of seeing some of their installations, notably one in which electricity was just in the process of being used for replacing a steam engine. This firm usually prefers to drive its mining hauling engines of the large size by means of ropes, and the smaller sizes by gearing. An example of the former is shown in Fig. 18, page vii.

This is installed in the Broughton and Plas Power Colliery near Wrexham, where there are a number of electrically-driven haulage plants at work. The particular gear which we illustrate is situated at a point 1130 yards from the shaft bottom. It is driven by ropes by a 150 brake horse-power continuous-current motor, and it is provided with three drums for endless ropes. This gear is of specially heavy design, the rope wheels being 6ft. 6in. diameter, and each fitted with Hall's type of friction clutch and automatic brake, the clutch and brake being operated by hand wheel from the driving platform. The driving pulley is 8ft. in diameter, grooved for nine ropes 1¼in. diameter. This haulage gear is constructed to deliver about 850 tons to the pit bottom per shift of eight hours, the total length of road operated being 4470 yards. A haulage-room switchboard is provided near the motor, consisting of enamelled slate

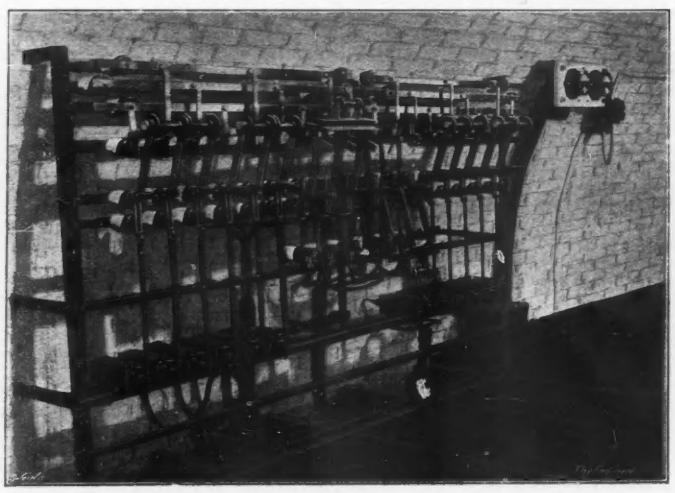


Fig. 16—DISTRIBUTING BOARD, TY TRYST COLLIERY

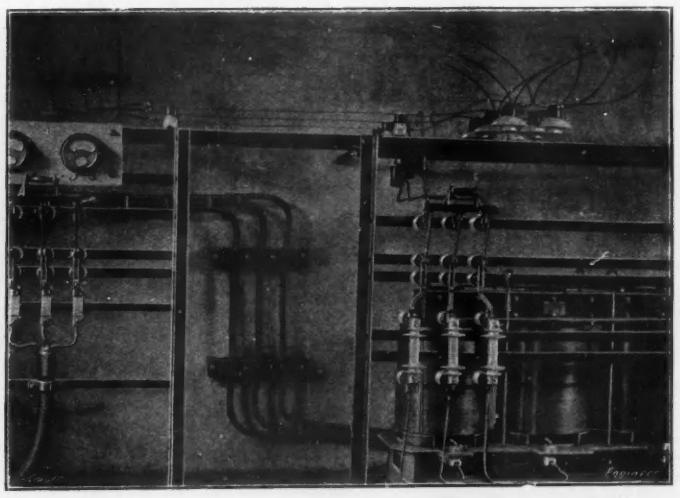


Fig. 17—TRANSFORMERS AND SWITCHBOARDS, BEDWELLTY COLLIERY

base mounted with double-pole switch and double-pole fuses, ampère meter, recording ampère meter, and volt meter. A double-pole liquid switch is also provided for starting purposes. Another 150 horse-power motor is at work at the shaft bottom driving an existing haulage gear through ropes.

At Gatewen Colliery, which is situated 2000 yards away from the Broughton and Plas power generating station, there is a large endless rope haulage gear with three rope wheels, driven by a 200 brake horse-power electric motor. The motor and haulage gear are fixed at a point 1200 yards from the shaft bottom, and the motor drives on to the gear through ten cotton driving ropes, each 1¼in. diameter. The haulage gear is like that shown in Fig. 18, and is also of a specially heavy design, the rope wheels being 6ft. in diameter and each fitted with one of Hall's type of friction clutch and automatic brake, the clutch and gear for each rope being operated by hand wheel from the driving platform.

Another type of hauling gear made by this firm is shown in Fig. 19, below. In this case the drive is direct through worm and helical gearing. The motor is of the two-pole undertype, and is of 50 brake horse-power. The two drums are fitted each with a band brake, and either can be put into gear by means of a clutch. The levers working the brakes and clutches are placed close together. The worm is of steel and the worm wheel of phosphor bronze; the helical gear is of steel. This plant would do equally well for winding as for haulage. Indeed, we understand that one installation has been supplied with this idea. Here again we would draw attention to the compactness obtainable by the use of an electric motor when geared direct to its work.

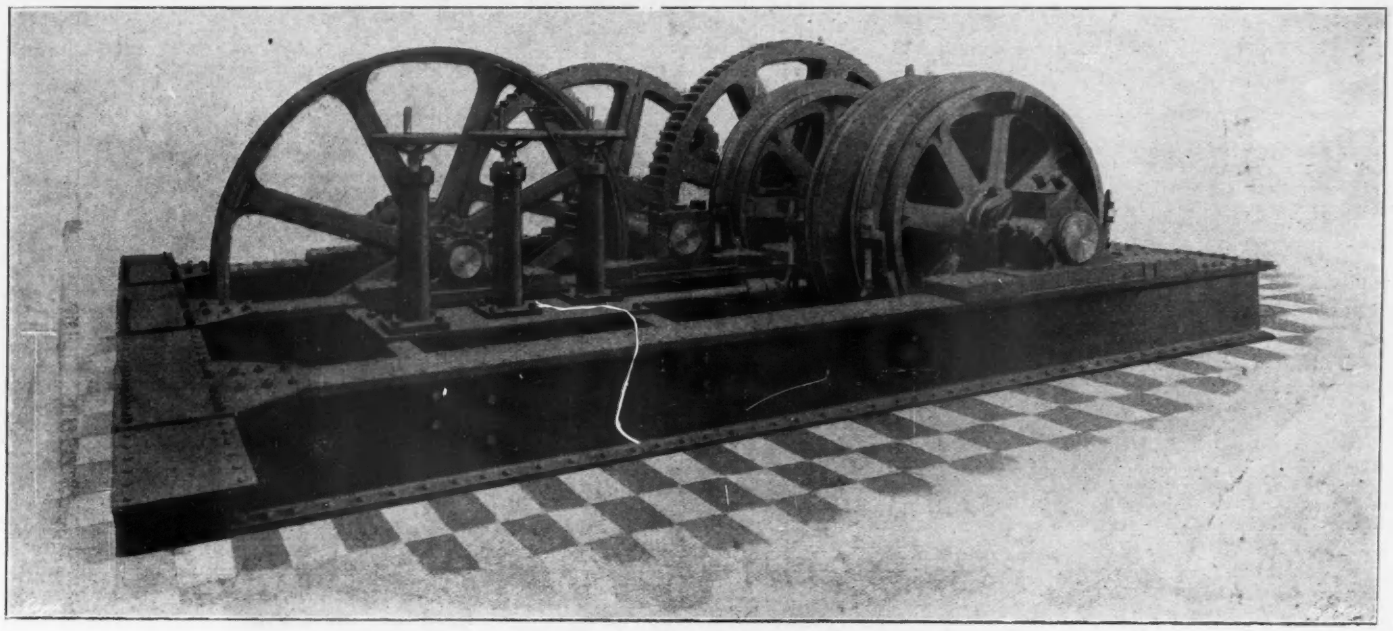


Fig 18—THREE-DRUM HAULAGE GEAR FOR ELECTRIC DRIVING

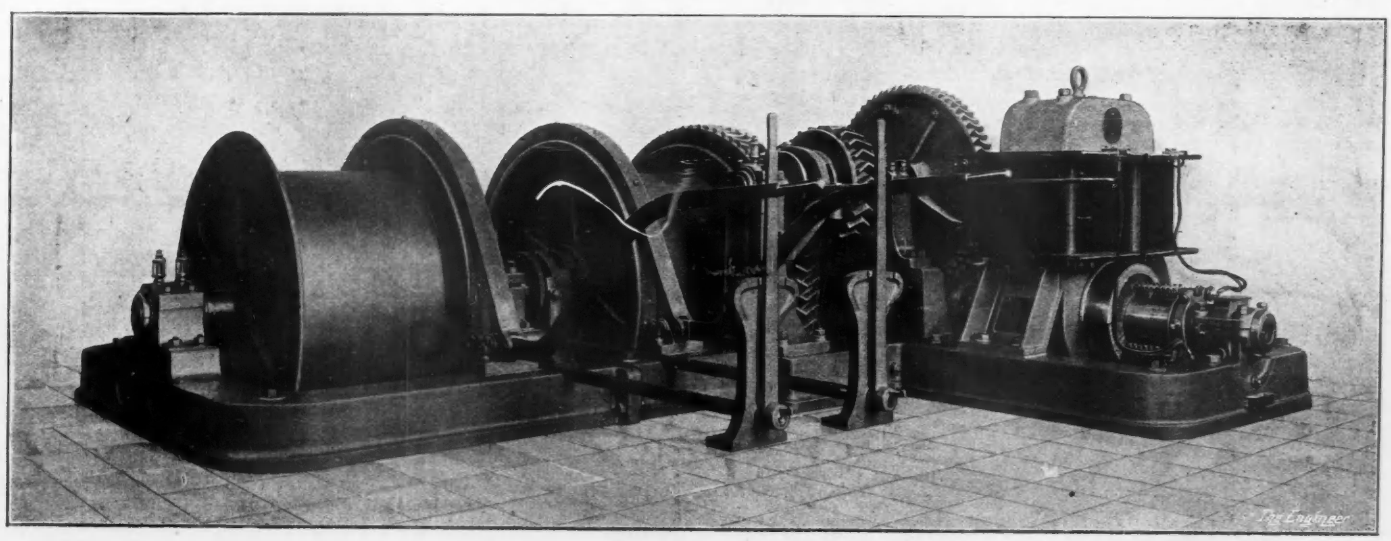


Fig. 19—MOTOR DRIVEN DOUBLE HAULAGE PLANT

Messrs. Mather and Platt, of Manchester, make a substantial form of hauling gear which is worthy of a somewhat extensive notice. We have previously drawn attention to the absolute necessity of having colliery machinery strong enough to stand rough usage. It is quite a different matter working below ground to what it is on the surface, and the makers in this instance have fully realised this. Another feature which has been observed is accessibility of parts and capability of easy subdivision. The bed-plate of this machine is made up of rolled joists, bolted together in such a way that they can readily be taken apart and got down a shaft. The motor in this particular instance is one of the firm's standard steel-clad open-type continuous-current motors, with a machine-cut pinion, which engages with a gear wheel mounted on a cross-shaft, carrying on its other end a helical pinion. This, in its turn, engages with a helical wheel, keyed to the main driving shaft. On this main shaft, and capable of being connected to it by friction clutches, are two hauling pulleys for working two separate roads. Both of these are 7ft. in diameter. They are of cast iron, and the driving face in each case is made up of a number of segments of wrought iron, which are bolted to the pulleys, so as to act as the driving surface for receiving the endless rope, and so as to be readily removed and replaced when wear has taken place. Four hand wheels will be noticed on the driving platform. Two of these are for actuating the clutches, and two for the band brakes. The clutch forms the subject of one of the firm's patents. It consists of a friction boss attached to the pulley, a fixed sleeve on the shaft, and a friction band. The sleeve is provided with a flange, and is of sufficient length to carry the friction boss and the pulley. It is keyed on to the driving shaft by means of a key provided with a gib head and carrying a set screw. To the flange on the sleeve is bolted the friction band, which embraces the boss on the pulley. The friction band is made in two parts, which are connected together by a pair of right and left-handed sets of screws working in two lugs on the halves of the friction band. To these right and left-handed screws are rigidly connected two arms connected by links to a loose sleeve, which is worked by a shifting fork. When the loose sleeve is pushed towards the clutch the two arms are thrown away from the shaft, and the right and left-handed screws are turned in such a manner that they draw the two halves of the friction band together. The result is that the boss on the pulley is gripped, and the pulley revolves with the shaft. The whole of this gearing is enclosed in cast iron casing, to keep out the coal and other dust. Each pulley has a band brake worked by a hand wheel. It will be evident that either pulley or both may be worked, and in the particular machine illustrated each is intended to take a maximum working load of 30 horse-power. The machine is illustrated in Fig. 20 page viii.

We have said that the motor shown is for continuous current. The makers, however, have supplied the same plant for working with polyphase motors. Here the friction clutches come in most usefully, as the motor can be run up to speed with practically no work on it. It may be, too, that it is desired that the hauling plant should be worked in a place where there is either a considerable amount of water or where there is fear of gas. In this case the motor shown in Fig. 21, page ix., would be employed. This is claimed by the makers to be absolutely air and watertight. Special end covers are employed with their flanges turned to fit the turned-up edges of the steel yoke casting. The end covers are of cast iron, and are solid. The cover at the commutator end has an opening on either side to admit of access to the brush holders, the openings having hinged lids which fit down tightly. They are provided with a window, which may either be of mica or covered with a very fine mesh wire gauze. The cover at the pulley end has no openings at all. It will be observed that the steel casing is heavily ribbed so as to dissipate the heat generated.

A compact and well-arranged hauling plant is shown in Fig. 22, page ix., which represents one of a pair of exactly similar machines which were supplied some little while ago by Messrs. Mavor and Coulson, of Glasgow, to the Dalmeny Oil Company for use in its collieries. As will be seen, the motor and all the remainder of the hauling gear are mounted on one bed-plate. The motor is of the four-pole type, and of 60 brake horse-power. A pinion on the motor shaft, on the end, remote from the commutator, engages with a gear wheel, which is carried on a shaft. This shaft has mounted on it another pinion, which, in its turn, gears with the toothed wheel on the main shaft, which carries the hauling drum. Arranged near together, so as to be readily worked by one man, are the controller—which is very similar in appearance to an ordinary tramway controller—the clutch lever, and the

ELECTRICALLY-DRIVEN DOUBLE HAULING ENGINE

MATHER AND PLATT, LIMITED, MANCHESTER, ENGINEERS

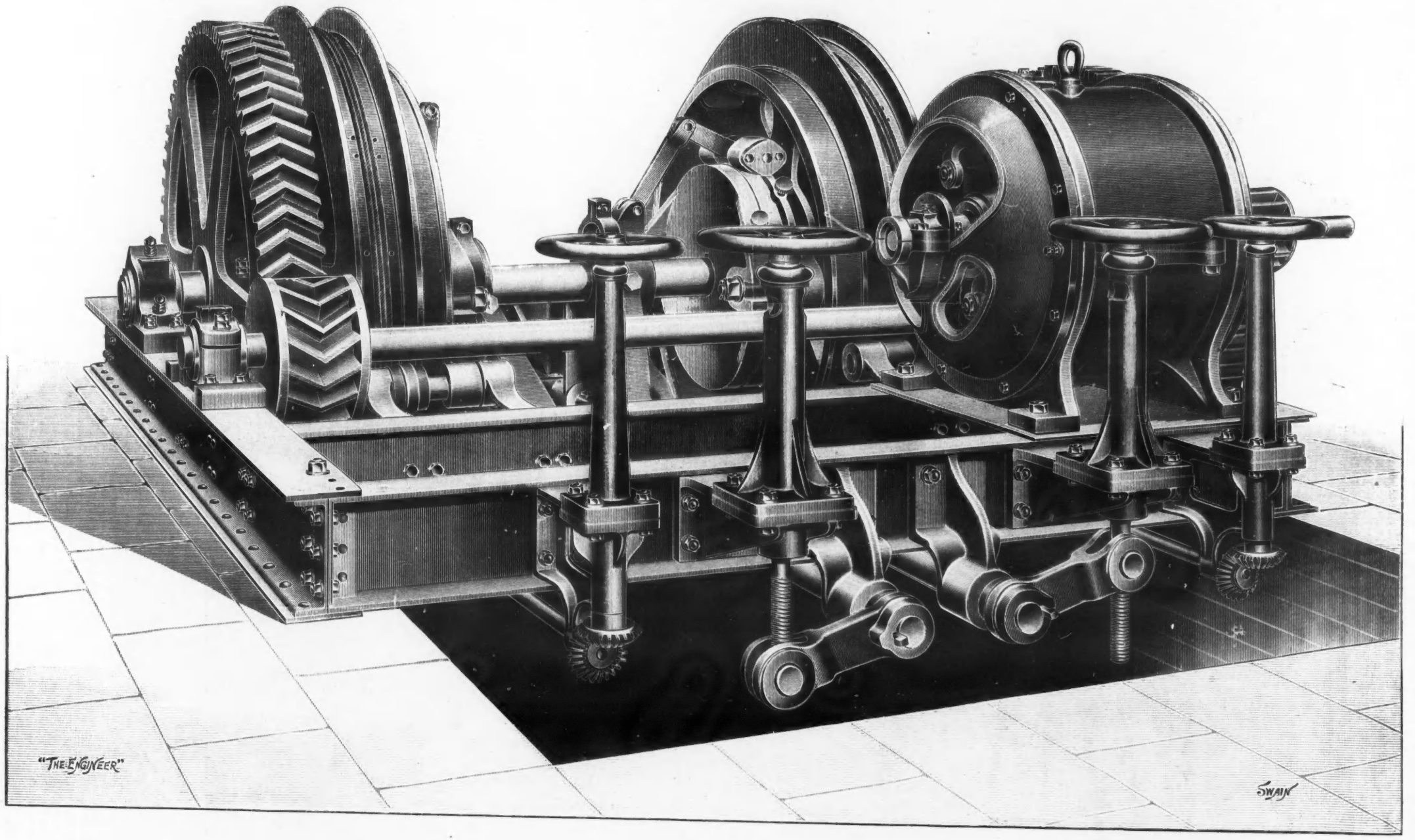


Fig. 20

brake lever. The total length of the haulage worked by this plant is 312 yards; the maximum gradient is 1 in 2, and there is some 110 yards of this; the total vertical rise is 300ft. One haulage rope is used, and its diameter is ⅜in. The gauge of the rails is 3ft., and the rails themselves are made of angle iron, weighing 21 lb. to the yard The tubs run on 13in. wheels, and weigh 5 cwt. when empty and an average of 1 ton when loaded. During a

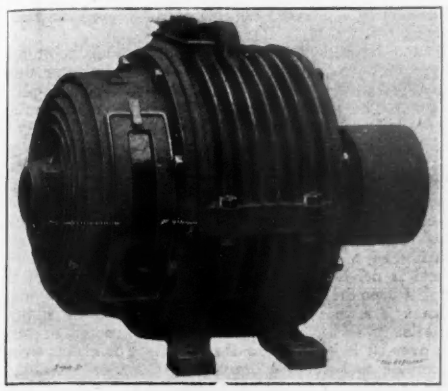


Fig. 21—ENCLOSED TYPE MINING MOTOR

test made of one of these hauling plants at its colliery it was found that the time taken to accelerate in hoisting was 15 sec.; the time occupied in running at full speed, 2 min. 57 sec.; and the time taken to retard, 2 seconds. These times add up to 3 min. 14 sec., which represents an average of 3½ miles an hour. A complete cycle from starting to wind to starting to wind is performed in 8 minutes, so that 7½ cycles are got into the hour. In ordinary working five tubs, each weighing 1 ton fully loaded, are hauled at each lift, so that with 7½ cycles this represents a total of, say, 28 tons per hour. The number of watts taken to start the haulage was 28,200; the number absorbed during acceleration, 25,850; and the number during maximum speed on the maximum gradient, 30,500. An important point in colliery work is to have the various parts of which a machine is composed made as small and easily handled as possible. It will be seen that this point has not been forgotten in the present machine. The two ends of the bed-plate are separate from the sides, but are attached to them by bolts.

The following particulars in connection with these plants are of interest. The drums are 3ft. 6in. in diameter, and are provided with flanges. They are large enough to hold 200 fathoms of ¾in. rope. Each drum is built up of two cast iron cheeks, and is cleated with ⅜in. steel. The cast iron cheeks are bushed with gun-metal, and one has cast upon it a flange for the brake, while the other has cast upon it claws for engaging with a clutch on the shaft. The brake is of the ordinary band type, and is operated by foot. The drum at full speed will make 34 revolutions per minute. The spur on the drum shaft is 4ft. 6in. diameter and 7in. wide on the teeth, which are 2¼in. pitch. The pinion on the intermediate shaft is 1ft. 3in. in diameter, the width and pitch being the same. The spur on the intermediate shaft, which revolves at 122 revolutions per minute, is 3ft. 6in. in diameter and 6in. wide, the teeth being 1¼in. pitch. This gears with a raw hide pinion 12in. in diameter, which is keyed to the motor shaft, which revolves at 425 revolutions per minute. The armature of the motor is of the slotted drum type, the slots being lined with insulating channels before the winding is put on. The armature coils are former wound. The magnet coils are also wound on formers, and are detachable from the pole arms.

Figs. 23, 24, and 25, pages ix. and x., represent three haulage plants which have been electrically equipped by the Electric Construction Company. The first of these is a double drum haulage fitted with screw-down friction clutches for operating the drums, these being worked by hand wheel. There is also a foot brake gear. The motor is of the open four-pole type, and it is started up with a controller similar to those used on tramcars. The haulage gear itself was made by Messrs. Heenan and Froude. Fig. 24 shows a single drum haulage. The motor in this case is of the totally enclosed type, and it drives the haulage drum through double reduction gear. The drum can be thrown into gear by means of a hand wheel and clutch. The whole can be mounted on wheels for moving about from point to point underground. Fig. 25 shows a neat and compact little endless rope haulage plant, which is driven through double reduction gear by an enclosed type motor. The various portions of this machine are easily taken apart, and the whole forms a workman-like job.

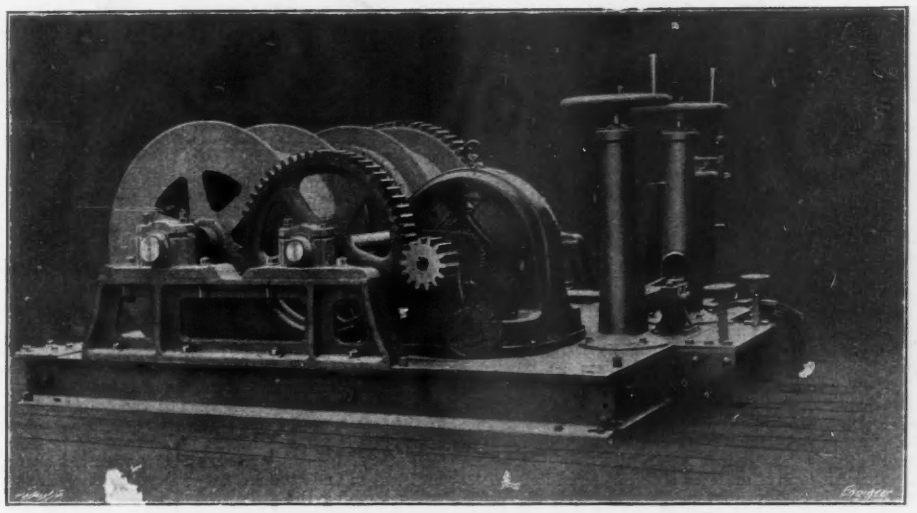


Fig. 23—DOUBLE-DRUM MOTOR DRIVEN HAULAGE PLANT

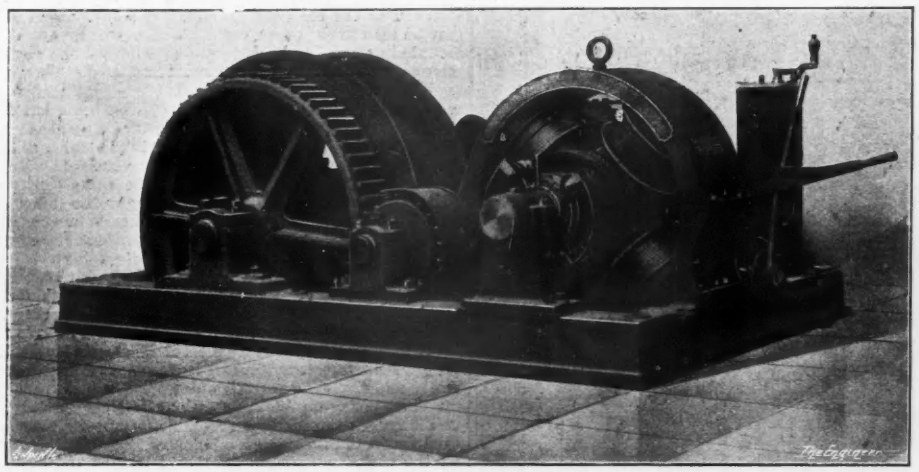


Fig. 22—SINGLE-DRUM ELECTRIC HAULAGE PLANT

COAL CUTTING.

IT is no part of our intention in the present Supplement to single out the machine of any one maker and to say, "This is the best electrically-driven coal cutter." Indeed, such a thing would only be possible after long and exhaustive trials, which would probably go to show that each type had special attributes of its own not entirely shared by all the others. We much prefer to think that each type has its own special uses and to describe the construction of several, setting out at the same time the maker's claims for them. The drill type of cutter pure and simple does not appear to be held in much favour in this country, and the electrically-worked coal cutters may be broadly divided into three classes, namely:—(1) The disc machine; (2) the bar machine; and (3) the chain machine. Through the courtesy of the makers we are enabled to describe instances of each of these types.

The Hurd, or, as its makers, Messrs. Mavor and Coulson, have called it, the "Pickquick" coal cutter, is shown in the engraving Fig. 27, page xi. We described this coal cutter at some length in our issue of March 7th, 1902, but in order to make this Supplement complete in itself we may repeat a few particulars. As will be seen from the illustration, the cutter consists of a bar—sometimes made taper and sometimes parallel—into which are fitted the cutting teeth. There is a spiral groove on the bar which serves to bring out the pieces cut away. The bar is arranged on a head which is capable of such movement that the bar can be turned in almost any direction, and can cut upwards or downwards, or at any angle. The motor driving the cutter is of the four-pole completely enclosed type, with two shunt-wound magnet coils. The armature is of the slotted drum type. If alternating current is used, then a motor of the three-phase type is put in. The motor is then of the squirrel cage type with slip rings. The stator core, with the conductors buried in its slots, is contained in a cylindrical cast steel shell with ribs cast upon it. The motor drives the bar through gearing, and it also drives the haulage gear through a worm on a continuation of the armature spindle on the side remote from the coal-cutter bar. The rate of feed can be altered while the machine is running. These cutting machines are made in three standard sizes. The power required to drive these are 12, 18, and 26 brake horse-power respectively. The depth of undercut in the three cases is 2ft. 6in. to 3ft. 6in., 3ft. to 4ft. 6in., and 4ft. to 6ft. respectively.

The makers claim a number of advantages of this type of coal cutter. The number of parts, they inform us, is fewer than in any other cutter. There are no bearings or rubbing surfaces under the coal where dust and dirt might subject them to excessive wear, an objection to which some of the machines in use are open. The cutters are capable of being securely fixed to the cutter bar and allow of simultaneous and easy inspection. The cut with this machine can be made either on the pavement or at the roof, or at any intermediate point, and the bar may be tilted to suit the rise or dip of the seam. Moreover, the angle at which the bar works may be altered at will while the apparatus is in operation, thus rendering it possible for the holeing to be made in the best position. It is further claimed that it is almost impossible for the bar to be choked or jambed, and there is nearly entire absence of end thrust. The coal it produces is said to be rounder and the waste less than from any other machine, as the loose coal is not dragged out and broken up.

The diagram given in Fig. 28, page xi., shows a reproduction of four continuous recording ammeter records made on four successive days with a medium-sized "Pickquick" bar coal cutter. These records were being made at a time when we visited the colliery where the machine was at work, though, as a fact, actual cutting was not going on while we were there. We have, however, been supplied with copies of the records by Messrs. Mavor and Coulson. It will be seen that in the first record the machine was cutting up hill with the gear end leading. In this instance 120 yards was cut in 5¼ hours, including stoppages. These amounted in this case to well over 70 min. If taken at 75 min., this would represent an actual cutting time of 4 hours—an average of 30 yards an hour or 18in. a minute. The average depth of cut was 3ft. 9in. The average voltage at the switchboard was 480, and the ampères consumed may be read on the diagram. The other three records, first, a cut of 120 yards in 5¼ hours including stoppages, the machine cutting down hill, haulage end leading; secondly, a cut of 120 yards in 5¼ hours including stoppages, cutting up hill, gear end leading; and thirdly, a cut of 120 yards in 5½ hours including stoppages, the machine working down hill, haulage end leading, and feeding by gravity alone. An examination of these diagrams show that the average current being used was about 15 ampères, though the machine was frequently working in full cut with 10 ampères. or even under. Taking the average at 15 ampères, however, this represents an expenditure of energy equal to $480 \times 15 = 7200$ watts, or, say, 9·65 horse-power. We may add the following details: The machine was working with a direct-current motor. The bar was tapered, and 4ft. long. The machine was on rails. The inclination was 1 in 5, the position of the holeing was at the pavement level, the holeing was done in coal, and the nature of the roof was "fakes." The seam was 2ft. 8in. thick. One man was employed in driving, two in rail-laying, and one in clearing holeings. The tonnage output per man per shift was 27½. The driver was getting 6s. 6d. per shift, the rail-layers 6s., and the man clearing holeings 5s. 2d. The cost of labour per ton was, as a total, 2·57d. The machine was cutting at the rate of 37·5 square yards per hour, or 150 square yards per shift. The electricity consumed per ton of coal produced was ·26 units. One hundred and ten tons were obtained in the shift, and 25 per cent. of small coal was produced. The duration of the shift at the face was seven hours, and from bank to bank nine hours. The makers claim that this expenditure of energy, amounting to only ·26 unit per ton of coal raised, is an exceptionally noteworthy performance.

The next cutter to which we shall draw attention is a disc machine, and it is made by Messrs. Ernest Scott and Mountain. This machine is made to work with three standard sizes of discs. These discs, 4ft., 5ft., and 6ft. in diameter, will undercut about 3ft. 6in., 4ft. 6in., and

5ft. 6in. respectively. An examination of this machine, which is illustrated in Fig. 29, page xii., will show that it is compactly designed and strongly put together. Its working parts are all enclosed, and its gearing runs on ball bearings and in an oil bath. The overall dimensions of the machine are 8ft. 6in. long, 3ft. 3in. wide, and 1ft. 2in. high from the rail to the top of the casing. The total height from floor to the top of the machine is, with rails, 1ft. 10in., and with skids 1ft. 8in. The total weight is approximately 42 cwt.

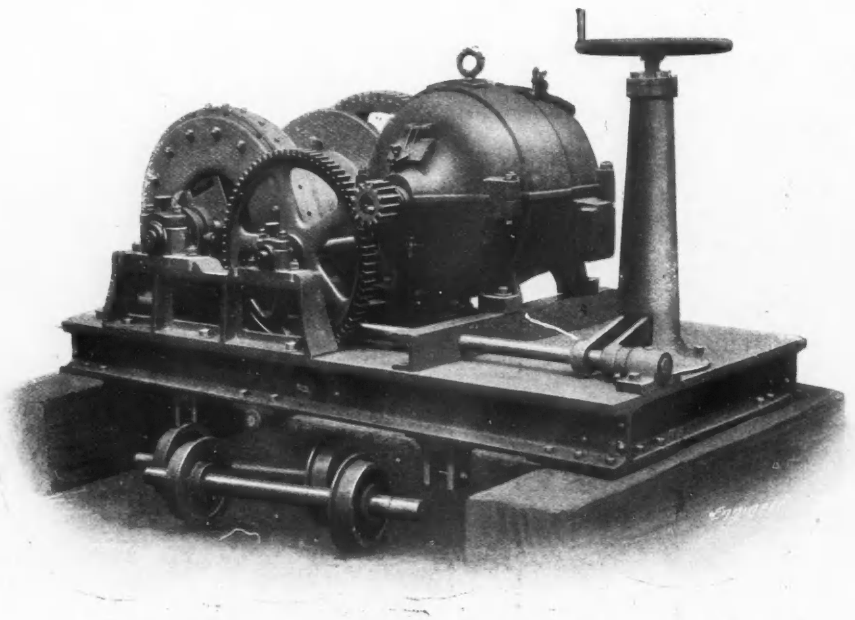


Fig. 24—PORTABLE SINGLE-DRUM HAULAGE PLANT

Another size of machine is also made by this firm which is intended for working thin seams. It can be made to work with the same sized discs as the first-mentioned machine, namely, discs varying from 4ft. to 6ft. in diameter, and permitting of an undercut varying from 3ft. 6in. to 5ft. 6in. The overall dimensions of this machine are 8ft. 10in. long, 3ft. 8in. wide, and 17in. high from the top of the rail to the top of the casing. The weight of this type of machine is 34 cwt., and it is to be noted that both types of machine are provided with motors of the same power, namely, 25 horse-power. This power is found by the makers to be that required in normal working, but we are informed that the motors are capable of giving from 30 to 40 horse-power for short periods, should the cutter become jambed or the work become suddenly very heavy. These coal-cutters are only used for the long-wall system of working, and we understand that there is only a small demand for machines to work on the board and pillar or on the pillar and stall systems. The essentials required for satisfactory coal-cutting with these machines are a good floor and roof, and that the material in which the cutter disc works should not be too hard, and as free as possible from ironstone balls.

The motor casing is made of steel, and there are but two poles, these being placed on the horizontal diameter. A portion of one of the poles is removable, so that the armature may be readily got at and taken out if necessary. The armature shaft is prolonged at both ends, passing out of the enclosed case, in which the armature runs through glands. One end of the shaft drives the disc through bevel gearing and a toothed wheel engaging with the slotted teeth on the cutting wheel. The other end of the shaft works the feed gear, which is adjustable in throw, and works in an oil bath. There is an idle pulley on the rope drum to carry the rope back under the machine when cutting backwards. In connection with this feed gear we may mention that the drum which hauls on to the wire rope, thus drawing the machine along, is made to run freely on its shaft, but is capable of being clamped to it by the action of a winged nut, which works on a left-handed screw on the pulley shaft. In ordinary working the revolution of the pulley only tends to tighten it on its shaft by reason of this left-handed screw, but if for any reason it is necessary to stop the feed of the machine, a slight blow with a hammer is sufficient to undo the nut and to allow the shaft to revolve without taking the pulley round with it. It is claimed that this is a most important feature.

All the working parts of this machine, including even the bearing of the cutting wheel, are enclosed, and the motor runs in what we are informed is a gas-tight case. There are, however, openings for examination and adjustment which can be hermetically closed by means of doors. The motor requires in practice from 50 to 60 ampères, with an electromotive force of from 420 to 450 volts, and it is said that a machine of this type, when in fair working order and handled by men accustomed to the work, should be capable of cutting from 60 yards to 80 yards per shift, though under favourable conditions, where the undercutting is soft, 120 yards have, so we understand, been cut in one shift. The cutter disc is made in halves, and is arranged with a plain circular periphery, in which a slot is turned for securing the cutter boxes. These latter are arranged to hold straight cutters, which require a minimum of work to produce, and are more cheaply made than shaped cutters. The boxes themselves can be removed and replaced should they be damaged.

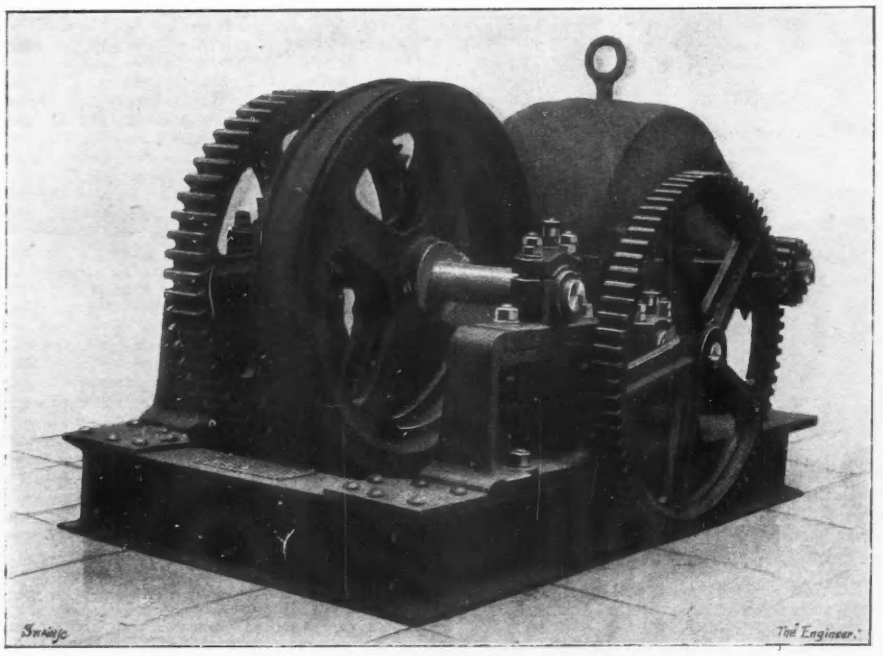


Fig. 25—ENDLESS ROPE HAULAGE PLANT

The switch gear is contained in two cast-iron boxes on the top of the machine. In one of these is the resistance, and in the other a multiple contact switch, which can be worked by handles from either end of the machine. A reversing plug switch is also provided to enable the machine to be run in the opposite direction if required. We had an opportunity of carefully examining one of these cutters, and could appreciate how space had been economised.

The illustration shown in Fig. 30, page xii., represents the coal cutter made by the Diamond Coal Cutter Company, and fitted with two 10 horse-power three-phase motors. The usual voltage for which these motors are wound is from 400 to 500, and the general periodicity 40 or 50 per second. The motors run at 700 revolutions per minute. They are of the slip ring type, are entirely enclosed, and are guaranteed to be gas-tight. There are four reductions in speed from the motors to the cutter wheel. The first is from the motors through bevel gearing to the intermediate shafts, thence through spur gearing to a common main shaft, whence the cutter wheel is driven by a bevel pinion. The feed is of the ratchet type driven by the motors, and it can be adjusted from half a tooth to seven or eight teeth at a time. Practically the whole machine is constructed of steel. Its over-all height is less than 20in. The cutter wheels are made to hole to a depth of 4ft. 6in. or 5ft. 6in., as may be desired, and the holing is done at the floor level.

The machine is what the makers call their standard "longwall" type. It is mounted on sledges, and is fitted with a recently patented steering apparatus. The body of the machine runs on two broad steel angles. The front end is prevented from digging into the coal by the extended fender shown, and on the gob, or goaf, side is a similar fender extending forward, and a long trailing rod or rail, which may be 12ft. or 15ft. in length, is hinged from the centre of the goaf side sledge, and adjusted by means of a screw at the back end of the machine. All these fenders may be adjustable, and made so as to suit

Fig. 26—STARTER AND CONTROLLER

given circumstances. The back end of the machine is further kept up to its work by a hauling rope being attached to the rear end by means of a long rod, which may be seen in the engraving. These machines are also mounted on carrier wheels to run on rails, but the sledge arrangement is now more commonly adopted. They are made to cut backwards or forwards; it is only necessary to reverse the steering apparatus, bolt holes being left for that purpose. The cutting tools are reversed by changing round the detachable boxes—the subject of another of the firm's patents—and the switch is also reversible.

There is, of course, no novelty in the mounting of "longwall" coal cutters on sledges, but owing to the difficulty of keeping the machine up to its work this system has not been much used. The makers of this machine, however, claim that the adoption of their method of guiding a sledge-carried machine has led to some excellent results being obtained. They have been making experiments for a considerable time with various arrangements in order to enable the simplicity of sledges to be made available in practical use. There is a great deal of time lost in laying the ordinary railroad along the coal face, though the comparative ease of spragging the rails and sleepers affords a reliable means of taking up the thrust, which has caused this to be the universal method. The guides which the Diamond Coal Cutter Company has now adopted afford, it is claimed, all the stability required—the long trailing rod butting against the props at a considerable distance behind the machine, where a good leverage is obtained. At one colliery, where some of the older pattern "Diamond" machines have been converted to run on sledges, the following results have, so we are informed, been obtained:—In a seam about 4ft. thick, 500 yards of face were undercut to a depth of 5ft. 6in. in inferior coal interspersed with pyrites in 15¾ hours, and, subsequently, in the presence of several representatives from other collieries, 200 yards of the same face were undercut in 5¾ hours. These, it is claimed, are records for "longwall" coal cutting. It is further asserted that by the use of sledges fewer attendants are required, because no rail-laying is necessary.

The Diamond Coal Cutter Company claims to have had the largest experience of any firm in this country in polyphase coal cutter working. It, of course, uses direct

THE MAVOR AND COULSON "PICKQUICK" COAL CUTTER

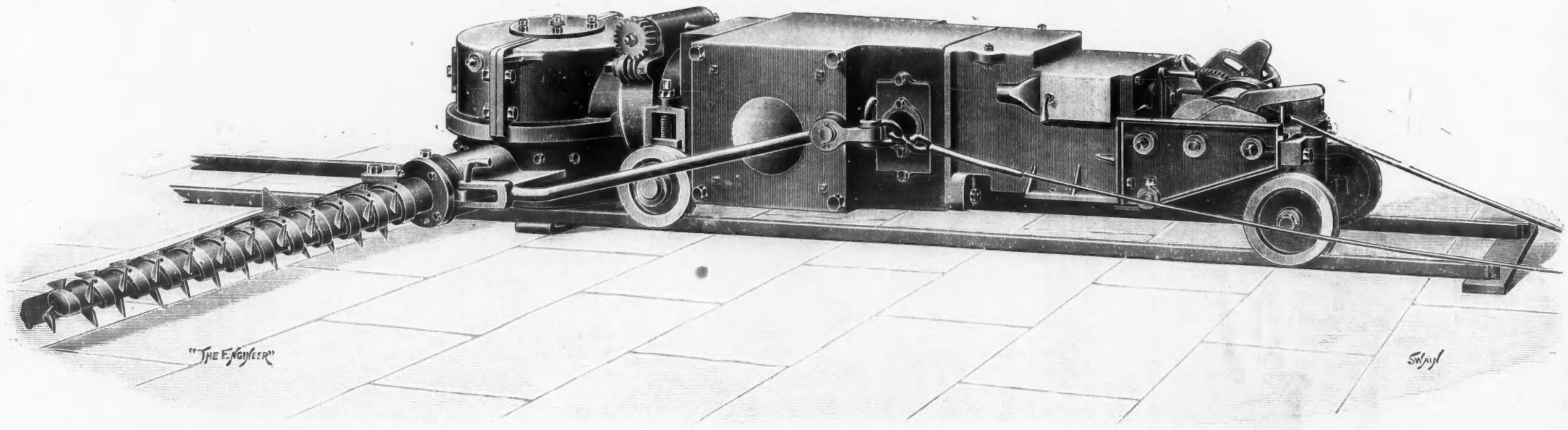


Fig. 27

current motors as well for this work. It is the firm's opinion that there is undoubtedly a large field for polyphase machines, but that whether in the long run they will prove quite so satisfactory as the continuous current machines, experience only can decide. It will be interesting for our readers to compare this view with that of Mr. Holiday, of the Ackton Hall Colliery, given in another column. He, it will be seen, is a strong advocate of three-phase current for mining work, and particularly coal cutters. The motors fitted to the machine illustrated in Fig. 30 are designed to give their full horse-power continuously without overheating. With regard to repairs, the firm has not found that there is any great difference between the cost of either system—direct or polyphase—provided the machines in each case are equally suitably designed.

Another form of electrically-worked coal cutter is that made by Mather and Platt. It is shown in outline and elevation in Figs. 31 and 32, pages xii. and xiii. This machine is at present made in two sizes, Nos. 1 and 2, the particulars of which are as follows:—

	No. 1.	No. 2.
Length	8ft. 6in.	6ft. 6in.
Breadth	2ft. 2in.	1ft. 10in.
Height	2ft. 2in.	1ft. 10in.
Weight complete ...	43 cwt.	23 cwt.
Undercut up to	6ft.	4ft.

Size No. 1 has been designed for seams of fair thickness and fairly level, while No. 2 is for thin seams with a bad roof and so unlevel as to necessitate the use of a lighter machine. These machines possess several points of difference from the others by different makers which we have described. The greatest of these, perhaps, is the fact that the cutting tools are carried on an endless chain which revolves on two wheels, one at either end of a jib, which can be racked horizontally through an angle of 180 deg. The construction of this machine will be readily understood by a consultation of the illustrations. The body is of cast steel, and it runs on two pairs of double-flanged wheels. The motor is carried midway between these two sets of wheels, with its spindle placed horizontally. The motor is of the totally enclosed four-pole type, and is made gas-tight if desired, while in all cases being made dust-proof. The top part of the casing is removable so that the armature can be got at and taken out if necessary. There is an observation door over the brushes, which shuts down on to machined surfaces, which, we are informed, can be made gas-tight. The spindle of the armature is prolonged at either end. At one end it is provided with a mitre wheel, which gears into another mitre wheel. This, in its turn, drives a four-thread steel worm working on to a cut phosphor bronze wheel. The thrust of the worm is taken on ball bearings. The other end of the prolonged armature shaft drives the feed gear, which consists of a steel worm and wheel, steel ratchet and pawl gear, this having a variable throw and a rope drum. The jib is made up of rolled steel plates, with planed chain slides and steel wheels. The chain is made up of alternate links of forged and cast steel, the latter holding the tools, which are all of identical shape. The switch is of the barrel type, and with the starting resistance can be quickly removed and replaced in case of need. The main gearing, switch, and resistance are all protected by a hinged cast iron cover. The gearing runs in an oil bath.

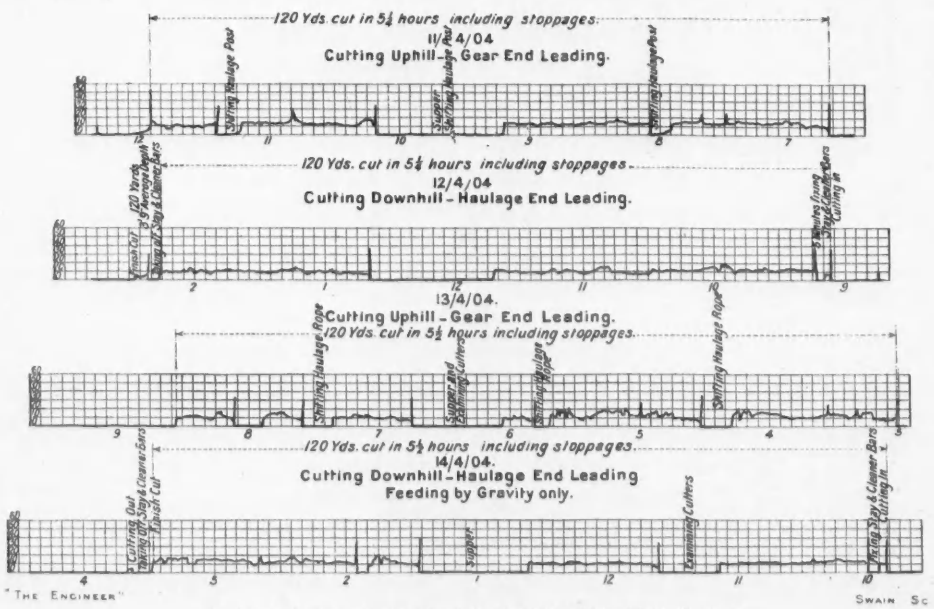

120 Yds. cut in 5¼ hours including stoppages.
11/4/04
Cutting Uphill - Gear End Leading.
120 Yds. cut in 5¼ hours including stoppages.
12/4/04
Cutting Downhill - Haulage End Leading.
13/4/04.
Cutting Uphill - Gear End Leading.
120 Yds. cut in 5½ hours including stoppages.
120 Yds. cut in 5½ hours including stoppages.
14/4/04.
Cutting Downhill - Haulage End Leading
Feeding by Gravity only.
"THE ENGINEER"
SWAIN Sc

Fig. 28—AMMETER RECORDS, THE "PICKQUICK" COAL CUTTER

With this machine the makers claim, amongst other advantages, that the "kerf" or "undercut" is absolutely cleared from *débris*, since the tools bring out all the loose pieces into the road; that owing to the narrowness of the chain-carrying jib the coal can be wedged or spragged up within 2ft. of the surface which is being cut, thus minimising the danger of the jib getting bound by the settling down of the coal after it has been cut; that the high speed of the working parts gives the tools sufficient momentum to overcome temporary obstructions, such as lumps of pyrites, without unduly straining the motor; and that the flexibility of the jib counteracts the evil effects of unlevel rails, and aids the tools in springing out the *débris* in pieces of considerable size without cutting or tearing action, thus enabling the tools to retain their edge for a long time.

For a six-foot undercut, 35 tools are used in the chain. These are small, plain, and of identical shape. The machine is designed to work right or left-handed on the long wall. The jib, as already mentioned, is made to swing through an angle of 180 deg. This swinging motion is brought about by means of a detachable ratchet lever, which works on to a square-headed spindle actuating a worm, which gears into the teeth of the worm-wheel at the back end of the jib. The jib cuts its way into the coal at the start, and does not, so we understand, require great space to be holed by hand before beginning each run down the face.

This type of coal cutter is probably the least used in this country, though it is in considerable favour in the United States, where, of course, the machine mining of coal is much more usual than it is here. It is, however, a type which seems to

possess some useful features. We confidently anticipate a great increase in the numbers of electrically-driven coal cutters in Great Britain. Were it for nothing else machine cutting has the great advantage of producing less dross and more round coal, but it must not be forgotten that machines very considerably reduce the amount of labour, and, indeed, produce a ton of coal for 6d. less in cost than is the case with hand labour. It will perhaps be said that compressed air will do all that electricity can accomplish, but there is no comparison between the difficulty in getting the power to the tool in each case. Electricity has by far the greater advantage.

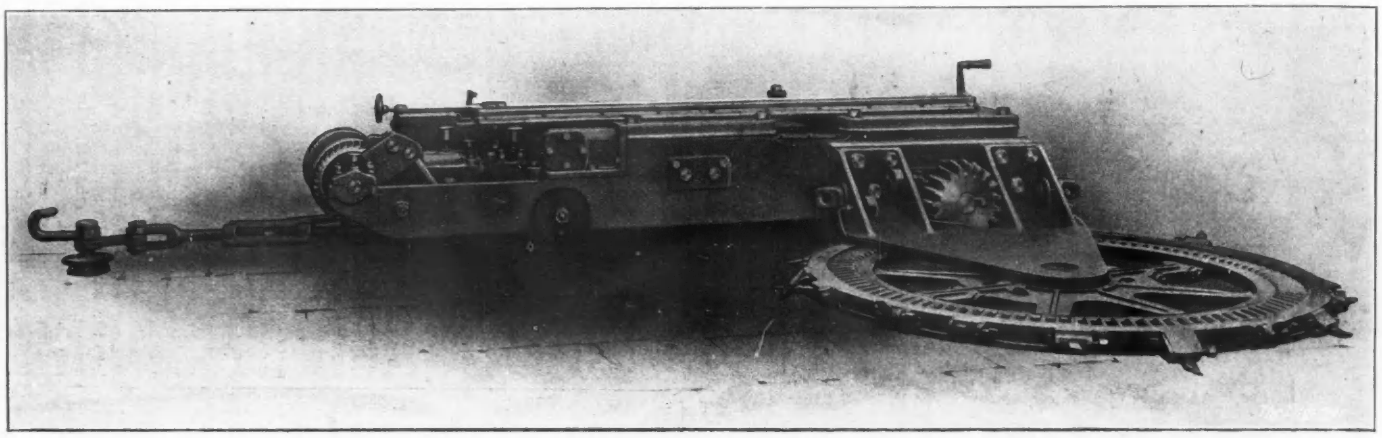


Fig. 29—DISC COAL CUTTER—ERNEST SCOTT AND MOUNTAIN

ELECTRIC MAINS IN MINES.

As might be expected, there is a considerable diversity of opinion as to which kind of mains or what system of running them should be employed in mines. This is, perhaps, the less to be wondered at, seeing the very different conditions under which mains are called upon to work in different localities. Thus, in one place the mine may be perfectly dry and free from water, while in others any amount of water may be met with. Then, too, the water may have destructive or damaging effects on protective coverings such as lead or even galvanised steel; or it may be of such quality as to have no effect whatever upon these metals. Again, in some mines direct current is used, in others polyphase. This of itself, of course, necessitates a varying number of cables. Here, again, different practices are favoured in different places. Thus some prefer concentric or multiple core cables; some two or more cables, as the case may be. Hence it is impossible to lay down any hard-and-fast rule on the subject. Even as to running the mains themselves, whether simple or compound, no single method is employed. When it comes to be considered what exceedingly diverse circumstances obtain, it is perhaps well nigh inevitable that this should be so. It may be, for instance, that in one colliery stationary pumping or hauling plants alone are required; in another there may be movable pumping plants or coal cutters. In one case the machinery may be close to the shaft bottom and removed far from any interference; in another the motors may be many hundreds of yards away from the shaft and subject at all times to danger of damage. Whatever the reason or reasons may be, there is a noticeable want of uniformity in this direction. We have had occasion to remark this during visits to a number of collieries quite recently, and as long as the mains serve the purpose required of them and serve it well, it does not appear to us to matter very much of what type they are or how they are run. We have seen mains taken along a heading simply suspended in marline loops. Such a method might appear crude, yet it answers its purpose, and has this advantage, that if any extraordinary pressure comes on the cable, such as a fall of roof, the marline breaks and the cable drops, while it is not subjected to any strain it cannot bear, and hence is not ruptured. Some colliery managers regard armouring of any kind as a danger which is latent, until by some injury the armouring comes in contact with the core; others would not dispense with armouring at any price. Some would not put in any but a lead-sheathed cable, others condemn lead as utterly unsuitable in every instance. It can, therefore, be said that there is no one standard method, and that each colliery must be equipped according to its own special features.

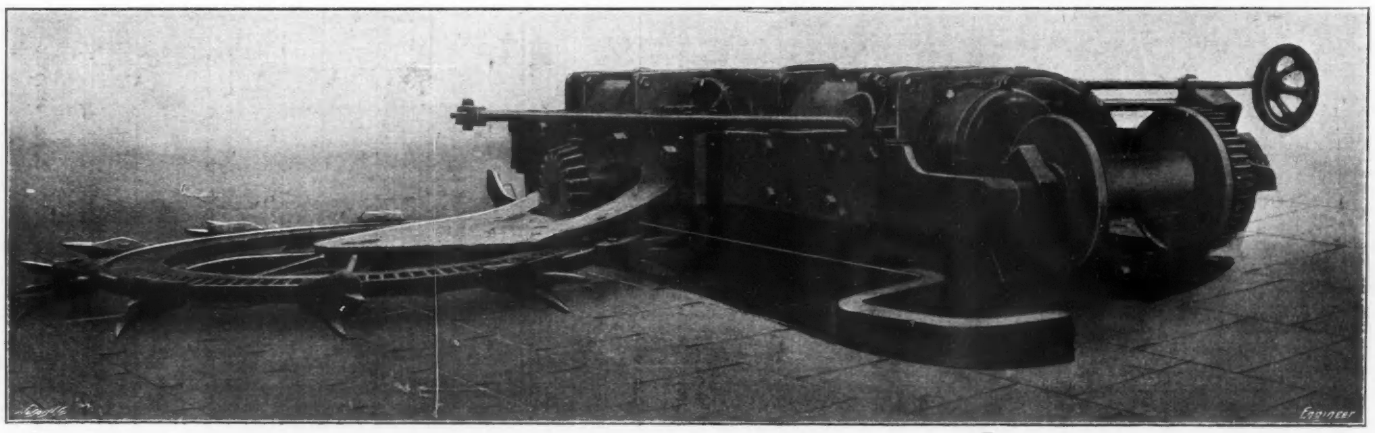


Fig. 30—DISC COAL CUTTER—THE DIAMOND COAL CUTTER COMPANY

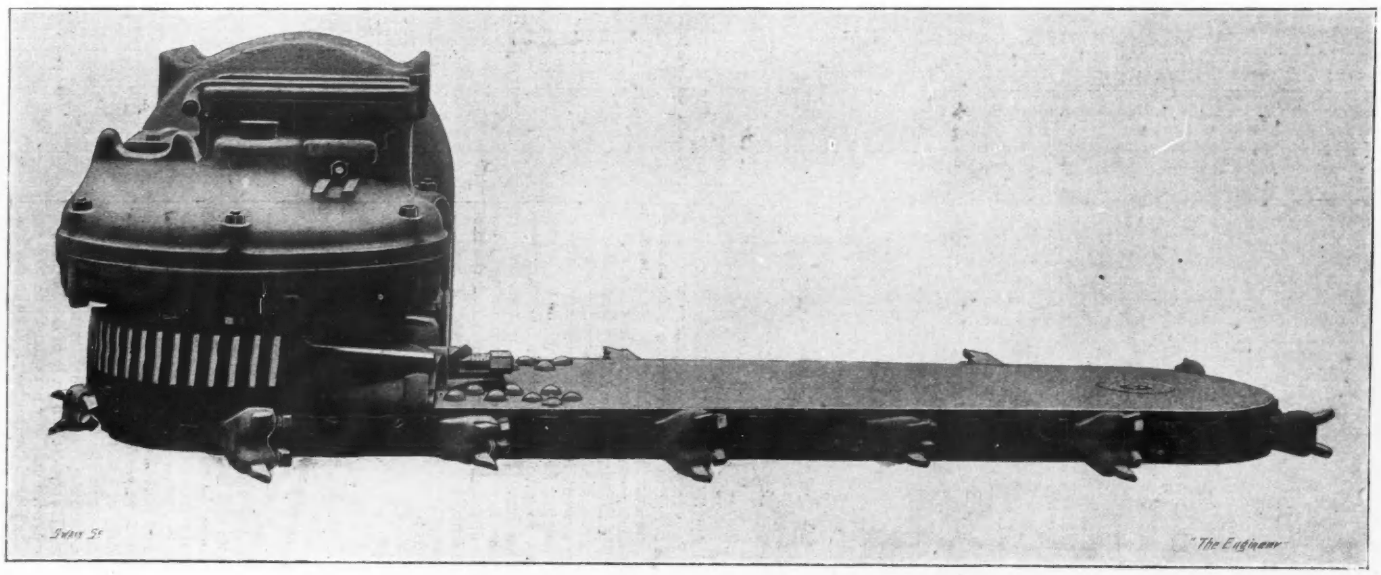


Fig. 31—CHAIN COAL CUTTER—MATHER AND PLATT

It is a noticeable fact that all our manufacturers are doing their utmost to make coal mining by means of elec-

tricity as safe as anything human can be. The cable makers are by no means behindhand in this, as will be amply evident by the various appliances which are shown in Figs. 33 to 42, on this and page xiv., and which are of the design and manufacture of Callender's Cable and Construction Company, Limited.

One of the most important things to attend to is the method of taking the main cables down a shaft. In another place we refer to the method invented by Mr. Holiday, of the Ackton Hall Colliery Company. Other methods are to take the cables down the shaft in oak or teak casing, or to clamp them in several ways on their way down the shaft in massive wooden cleats. Sometimes where the cleats come the cables are bound with marline, but this is not always the case. Messrs. Callenders have evolved a series of methods which may be chosen from to suit taste or convenience. The difficulties in the way are not to be ignored, for each hundred yards of, say, a 19-16 cable weigh some 70 lb. in copper alone, and when this comes to be multiplied by six, seven, or eight, the weight to be dealt with becomes considerable.

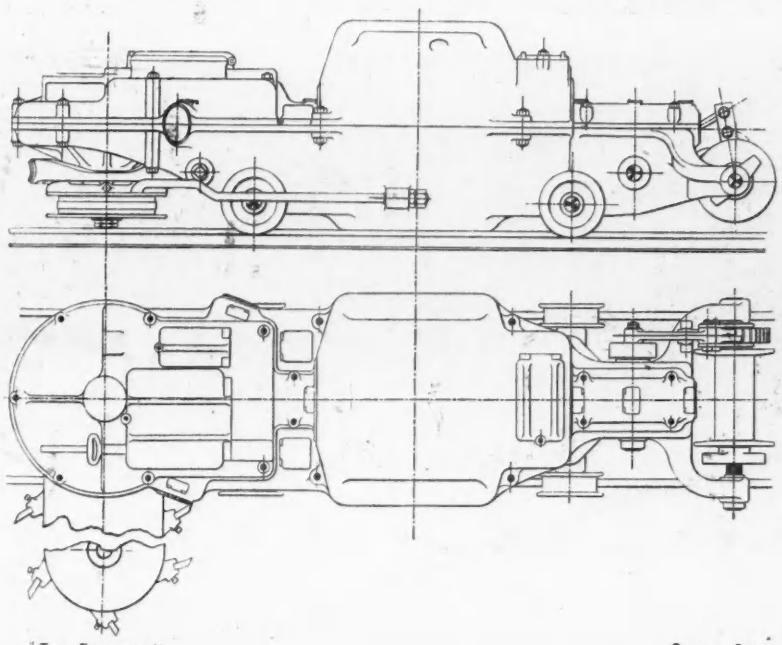


Fig. 32—THE MATHER AND PLATT COAL CUTTER

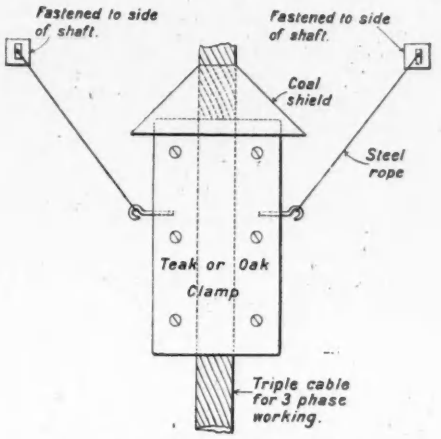

Fastened to side of shaft.
Fastened to side of shaft.
Coal shield
Steel rope
Teak or Oak Clamp
Triple cable for 3 phase working.

Fig. 33—METHOD OF CABLE SUSPENSION

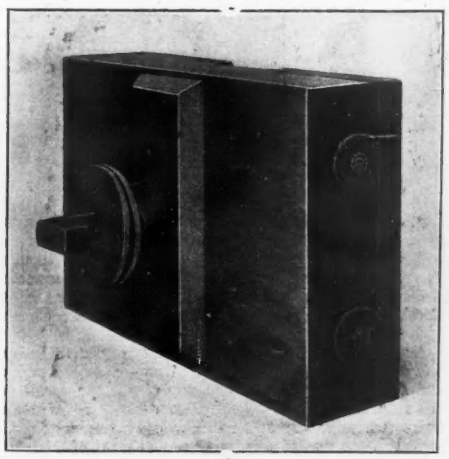


Fig. 34—SUSPENSION FOR USE WITH TUBBING

Messrs. Callenders' standard practice is to use for mine shafts a paper or jute insulated cable sheathed with vulcanised bitumen and double armoured. This cable, it is claimed, being mechanically protected, may be fixed in a shaft without any other covering, occupies but little space, is practically fireproof, and may very easily be manipulated when suitable fittings and clamps are provided. Some of the colliery engineers prefer rigid fixings for the cables being taken down shafts; others, on the other hand, think that the cable should be so hung that it can swing about should it receive a blow, deeming that it is thus less liable to receive injury. To such a system belongs the invention of Mr. Holiday, just alluded to. Mr. Holiday, however, prefers one suspension and one only. In the majority of instances, perhaps, there are more than one point of suspension—perhaps even as many as five or six in a depth of 400 or 500 yards. One of the methods of suspending a single three-core or triple concentric cable, to take an example, as devised by Messrs. Callenders, is shown in Fig. 33.

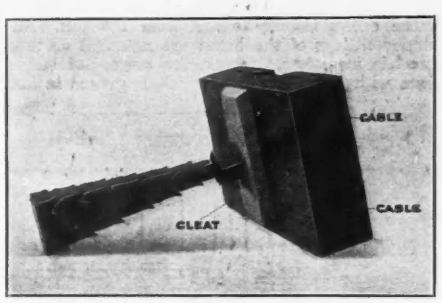


Fig. 35—CASING AND LEWIS BOLT

Here it is supposed that it is required to take a triple cable down a mine shaft for three-phase working. The cable is held in an oak or teak clamp—preferably the former—the cover of which is securely screwed to the back. Two hooks are screwed into this clamp, which is then hung by steel ropes to two eyes built or cemented or screwed into the side of the shaft, according to the nature of the lining. Then, in order to prevent the accumulation of coal dust on the top of the clamp and round the cable, a metal shield is provided off which the pieces which would otherwise rest slip easily. This is of all the greater consequence in mines where there is a lot of water, for the coal dust is certain to attract the moisture, and the effect might be serious. It can be well imagined that a device of this kind would allow of considerable vibration without injury to a cable. This method is, however, by no means universally employed. Judging from our experience we should say that the cable in the majority of instances is run down shafts without casing, but is held in a greater or less number of clamps secured to the lining of the mines, or to the buntons, in a variety of ways. In cases where there is tubbing or cast iron lining the engineers or managers are generally averse, and rightly too, to any holes not properly plugged being made in this lining. In cases where unplugged holes are not allowed the clamp may be held in position by means of a tightly fitting screw bolt, which will not permit of the ingress of water into the shaft. When, however, it is permitted to have an unplugged hole, Messrs. Callenders have devised a method by which the clamp or casing may be hooked in, the hole in the tubbing being made slightly oblong. This device is shown in Fig. 34. In this a single cable is shown secured in a clamp which is provided at its back with a right-angled hook. Such a method, of course, would be equally applicable to the fixing of casing.

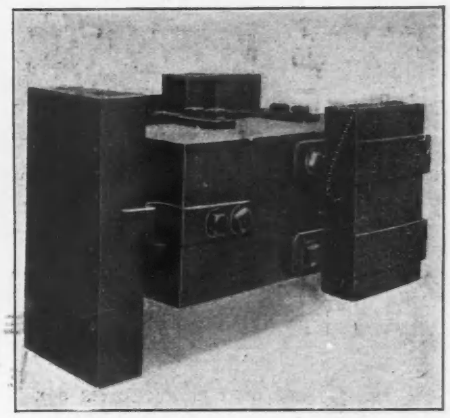


Fig. 37—METHODS OF FIXING CASING

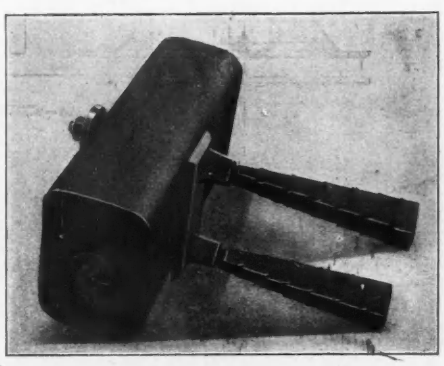
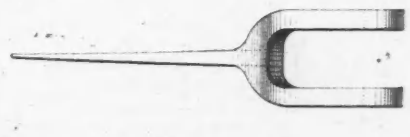


Fig. 36—CLAMP AND LEWIS BOLTS

When rock or brick lining is met with this firm suggests the use of lewis bolts. Figs. 35 and 36, show two examples of this method. The first represents two single cables in a piece of casing with a lewis bolt attached to it. The other shows a single triple concentric cable in a clamp, this being provided with two lewis bolts. In all cases it is most advisable that the cables should be kept well clear of the side of the shaft.



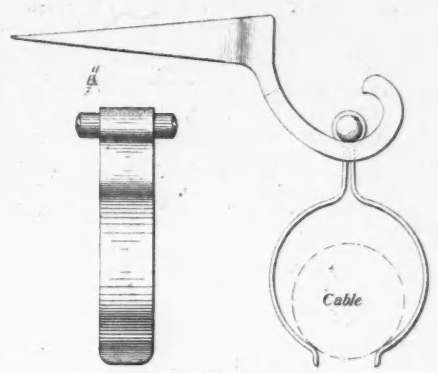


Fig. 38—CABLE SUSPENDER

Fig. 37, above, is interesting as showing three alternative methods proposed by this firm of securing casing or clamps to the buntons or baulks of timber which project from the side into the shafts of most mines. There can be no doubt that methods like some of the foregoing should be employed in the important business of taking mains down the shafts, but it has to be admitted that such care of the mains is not taken in every instance. One point should certainly be remembered, that is that accumulations of coal—especially, as already said, in wet mines—should be guarded against. As this may be

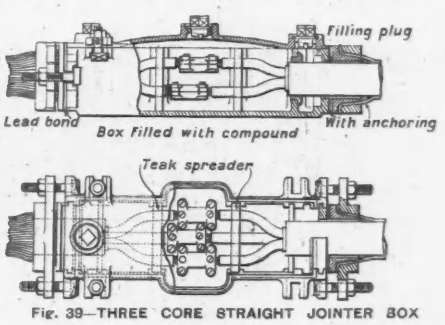


Fig. 39—THREE CORE STRAIGHT JOINTER BOX

readily and cheaply done, there is no reason why such a simple precaution should not be taken.

As to the cables in the mines themselves, these are all too frequently run without any very great regard to their comparatively fragile nature. An ingenious contrivance, which is shown in Fig. 38, page xiii., has just been patented by Messrs. Callenders. This, as shown, is made so as to be fixed by driving into the pit props or other timbers in a mine, but in another form it may be attached by means of coach screws. It will be seen that the clip holding the

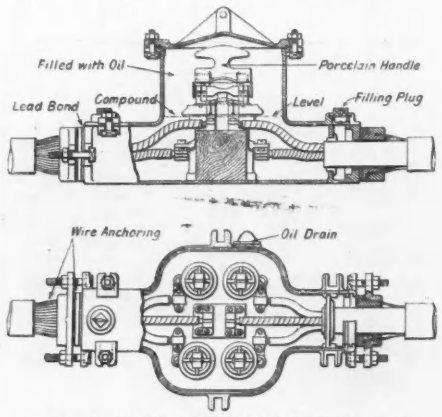


Fig. 40—THREE CORE DISCONNECTING BOX

cable is suspended from a hook in which it is quite free to move, so that any pressure or movement from the side is allowed for, and if it becomes too great the clip simply slips off the hook and the cable falls. Pressure from the top, such as a fall or sinking of the roof, is provided for by the nature of the clip itself. This is made so that any pressure much greater than that due to the cable itself causes the latter to be forced out of the clip and to fall. With such an appliance as this it should be well nigh

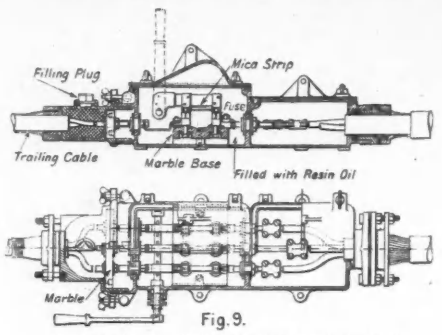


Fig. 9.

Fig. 41—THREE PHASE SWITCH FUSE BOX

impossible for a cable to be injured by any movement of the walls or roof of the heading.

Where it is necessary to make a joint in a cable this firm recommends the formation of an inset on one side of the road, and the placing in this of a straight through disconnecting box, or a switch-box. Figs. 39, 40, and 41, page xiii. and above, show three examples of boxes, which will explain themselves, and which are either of the disconnecting or non-disconnecting type, and one of which may be used either as a disconnecting or as a fuse box.

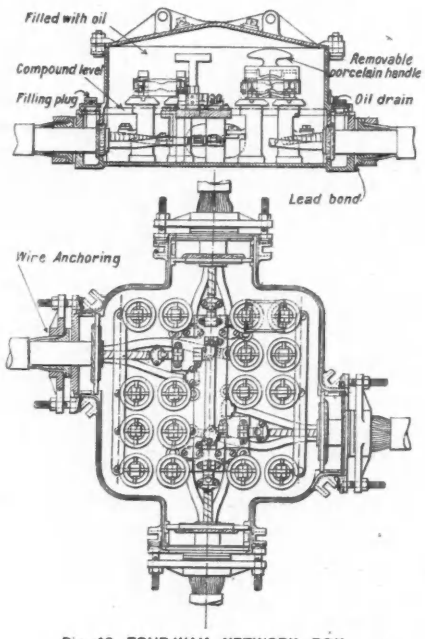


Fig. 42—FOUR-WAY NETWORK BOX

In this case, again, it must be remarked that such excellent means of making a really good job of the work are not always taken advantage of. Fig. 42, above, shows a four-way network box by the same makers, which is intended for a place where it is desired to take a number of offshoots from one main cable. All these boxes are rendered water and gas-tight by the use of a rubber grummet let into a V-shaped groove cast round the top of the box. The lid is also provided with a protruding V, which corresponds exactly with the V on the top of the box. The consequence is that when the nuts and bolts attached to the sides of the box and of the lid are screwed up, the rubber grummet is compressed in such a way that it is impossible for water to get through. The boxes are provided with anchor blocks for mechanically securing the steel wire armouring when cables of this character are used. These anchor blocks are designed with the object of ensuring not only a good mechanical grip, but also electrical continuity between the armourings of the cables leading to and from the box. All the interior fittings of the boxes are mounted on separate porcelain insulators. The cables are sealed inside the boxes with box compound, which is poured in hot and sets hard when cold. As will be seen, division pieces are provided, which prevent the compound spreading where it is not required. Then, too, in some instances, oil is used in addition for covering all the connections when these have been made. In Messrs. Callenders' disconnecting boxes the only tool necessary for removing the links or fuses, as the case may be, is a porcelain handle so shaped as to render shocks a practical impossibility.

THE ACKTON HALL COLLIERY.

ONE of the first collieries in this country to adopt electricity as a means of transmitting power on a large scale was the Ackton Hall Colliery at Featherstone, near Pontefract. We have recently been permitted, by the courtesy of Mr. Roslyn Holiday, the manager, to visit this colliery, and we have been much struck with the intelligence with which electricity has been employed there to assist in carrying on the great variety of work met with. Here we find electricity employed in almost every possible direction, the only exceptions being that it

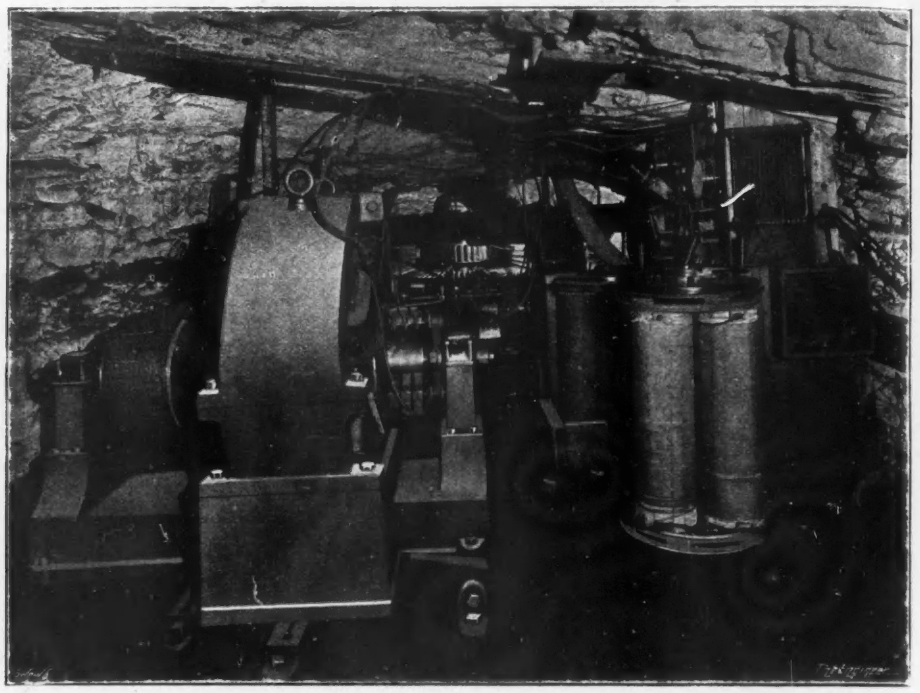


Fig. 43—MOTOR DRIVING HAULAGE GEAR

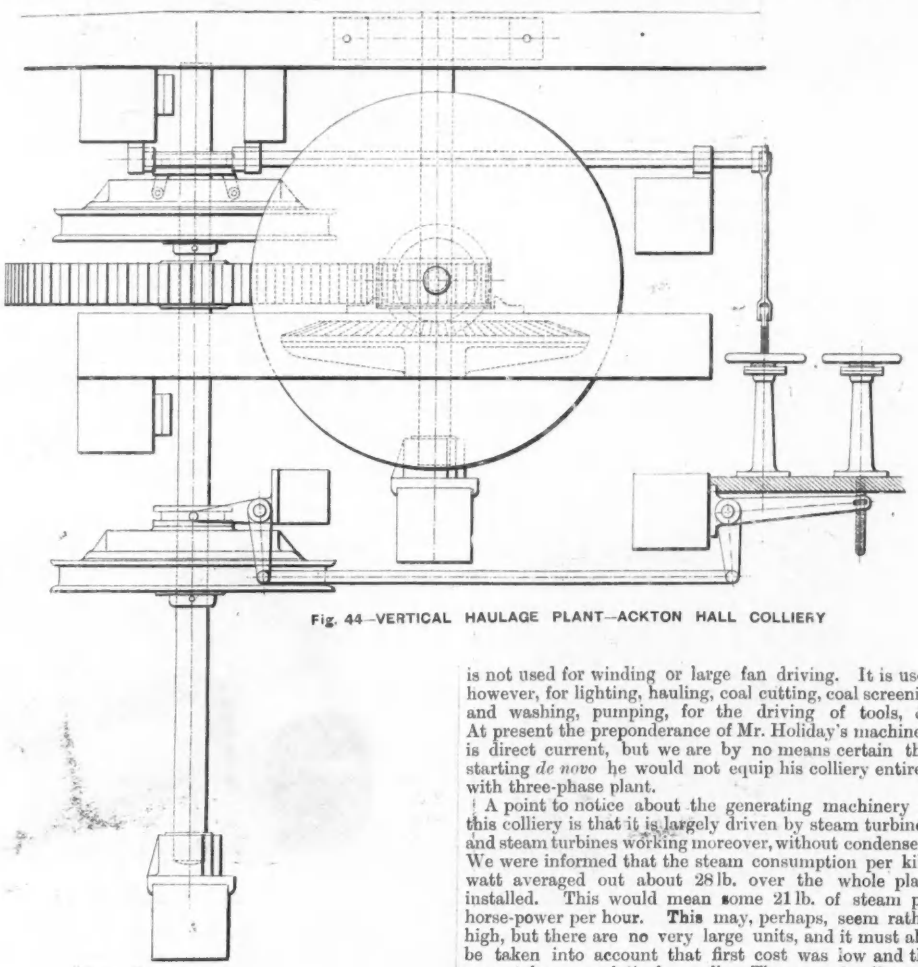


Fig. 44—VERTICAL HAULAGE PLANT—ACKTON HALL COLLIERY

is not used for winding or large fan driving. It is used, however, for lighting, hauling, coal cutting, coal screening and washing, pumping, for the driving of tools, &c. At present the preponderance of Mr. Holiday's machinery is direct current, but we are by no means certain that starting *de novo* he would not equip his colliery entirely with three-phase plant.

A point to notice about the generating machinery at this colliery is that it is largely driven by steam turbines, and steam turbines working moreover, without condensers. We were informed that the steam consumption per kilowatt averaged out about 28 lb. over the whole plant installed. This would mean some 21 lb. of steam per horse-power per hour. This may, perhaps, seem rather high, but there are no very large units, and it must also be taken into account that first cost was low and the space taken up relatively small. There are in all seven steam turbine-driven sets in the power-house. The details of these are as follows:—

	Volts.
One 300-kilowatt set, continuous current	500
Three 150 ,, sets, ,, ,, ...	500
Two 44 ,, ,, ,, ,, ...	110
One 150 ,, ,, three-phase ,, ...	320

In addition to these there are the following:—

	Volts.
One 40-kilowatt belt-driven continuous-current dynamo	110
One 20-kilowatt belt-driven continuous-current dynamo	110
One 10-kilowatt direct-coupled continuous-current dynamo	110

The belt-driven dynamos are run off a Robey compound engine, and the direct-coupled machine by a Bumsted and Chandler engine. Then there are two motor generators, one of these consisting of a 110-volt generator, coupled to a three-phase motor, and the other a 400-kilowatt continuous-current generator, coupled to a 500-volt continuous-current motor. In addition to the foregoing, there is also a 60-kilowatt rotary converter, 500 volts continuous-current to 320 volts three-phase.

There are no less than fifty-three motors, of various sizes, ranging in horse-power from 1½ to 80. These aggregate very nearly 1150 horse-power, and they are put to very diverse uses. Thus, to take the direct-current motors first, there are three 80 horse-power motors, one being used for an endless rope haulage, some 1½ miles in length, and two being used for working the Luhrig coal washer, which is capable of dealing with 1000 tons per day. There are four 60 horse-power motors, which work the coal screens and endless rope haulages. Three 40 horse-power motors deal with a disintegrator, an endless rope haulage, and a sawmill. There are ten 25 horse-power motors, working main, tail, and endless rope haulages, pumps, and the machinery in a brickyard belonging to the colliery, and situated some two miles away. Six 12 horse-power motors drive machinery in the stables, the colliery estate workshops, the wagon shop, and the coke oven hoist. Three 10 horse-power motors drive pumps. Three of 6 horse-power are employed in the joiners' shops and in working pumps. There are six of 4 horse-power engaged in like work and in driving the mechanics' shop, while there are five of 1½ horse-power each, which are at work in the lamp-room, for the lamp-cleaning machinery, for driving small fans, and for working pumps.

Altogether, there are some ten three-phase motors working in different places throughout the colliery. First of all there are four of 20 horse-power fitted specially to Hurd coal cutters made by Mavor and Coulson. To these we shall refer in more detail later on. Then there are one of 15 horse-power and four of 10 horse-power engaged in pumping, and one, also of 10 horse-power, working a heading machine.

To complete the electrical equipment there are thirty-five arc lamps and about 1000 incandescent lamps.

To give merely this list of electrical appliances and their applications affords but a faint idea of the ingenuity with which they have been employed. Taking the haulage at Ackton Hall Colliery first, we find that there are four separate installations. The largest of these is situated close to the bottom of one of the shafts. We illustrate it in Figs. 43 and 44, page xiv. It is interesting in more ways than one. In the first place, the motors are not mounted at ground level, but are erected on a platform carried on heavy timbers, the platform being built in a recess hewn out of the solid rock roof, and being well up out of the way of anything passing in the road underneath. There are two direct-current motors, of the type shown in Fig. 43. They are entirely open, as this part of the colliery is never likely to have gas in it. We noticed that brushes made up of thin brass strips were employed, and we were informed by Mr. Holiday that each motor man throughout the mine made his own brushes. The motors drive by link belting on to two pulleys connected with the gearing of the haulage mechanism. This, as will be seen in Fig. 44, is of the vertical type. It was constructed by Messrs. Qualter, Hall and Co., of Barnsley. This arrangement consists of two 5ft. diameter surging pulleys in halves, each fitted with a 3ft. diameter friction clutch, turned and bored and bolted to the arms of the pulleys. These are provided with renewable segments in the rim, and are brass bushed so as to run loose on an upright shaft which has two cast steel driving arms. On these arms are secured right and left-hand screws, fitted with levers, and brass nuts which carry the expanding semi-circular friction segments. These are actuated by means of levers connected to a sliding sleeve on the shaft, and are worked by hand wheels, screws, &c. The counter gear consists of a strong spur wheel made in halves fixed on an upright shaft. This gears into a pinion working on a counter shaft, on which is also keyed a bevel wheel made in halves, gearing with two pinions working on separate counter shafts on which are keyed strong belt pulleys for duplicate driving. When first put down, this plant only drove one haulage rope, this being some mile and a-half long. It later on became necessary to add another haulage rope of about the same length, and all that was done was to add another motor and another rope drum. On the occasion of our visit, this plant was working most smoothly and successfully.

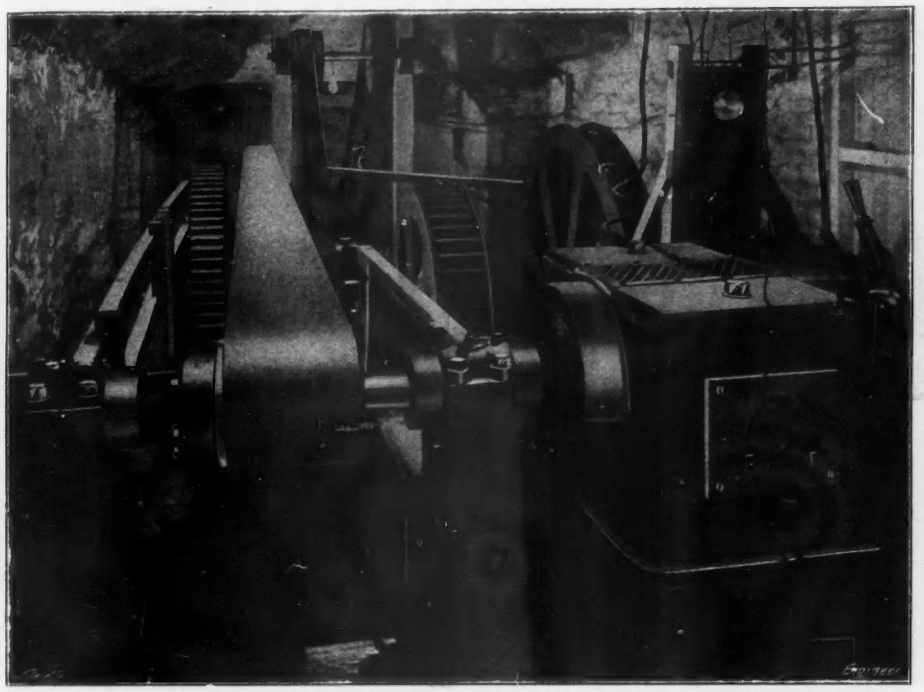


Fig. 45—BELT DRIVEN HAULAGE PLANT

The next most important haulages at this colliery are three driven by 60 horse-power motors. Perhaps the most interesting of these is situated some 1000 yards from the pit shaft, and is employed in hauling the tubs up an incline 600 yards long, and having a gradient of 1 in 6. The construction of this incline was rendered necessary by a fault being encountered which dropped the seam 60 yards. It is interesting to note that two seams overlie one another in this pit, the depth of earth between them being exactly 60 yards. The consequence has been that the upper seam has, at the fault, been found to come exactly at the level of the lower seam, and can be worked from the same level. The haulage plant working the incline is shown in Fig. 45, herewith. The motor, which is again of the entirely open type, drives the haulage mechanism through a canvas belt. The gear itself was constructed by Mr. Holiday, who used for it materials which he had at hand, and we may, perhaps, mention here that a point which struck us at this colliery was the way in which material at hand had been made use of. Special machinery for special work is by no means the order of the day, but rather the application of machinery already on the site in any direction which it might be required. Both Figs. 43 and 45 show well the conditions under which electrical machinery may be expected to work underground. Indeed, the conditions in both cases may be said to be above the average, for water is very nearly absent, and is, at all events, present in very small quantities, thus forming a complete contrast with many another mine.

In the back of the engraving, Fig. 45, will be seen a small countershaft secured to the rock roof of the machinery chamber. This works a small ram pump.

It will be unnecessary to go much further into detail with regard to the various haulage plants at this colliery. We may, however, draw attention to Fig. 46, below, which shows a plant wherein the motor is coupled direct to the gear and not through a belt as in the other instances. This gear was constructed by Messrs. Qualter, Hall and Co. It is carried on a steel girder frame, and can be moved from place to place as required. It consists of two hauling drums in halves, 4ft. diameter, bushed with brass, and working on a main shaft driven by means of jaw clutches. A spur wheel in halves is also keyed on the shaft, and gears with a pinion on the countershaft, on which is also keyed a machine-cut spur wheel gearing into a raw hide pinion on the motor spindle. The motor is of 25 horse-power. The whole of the brake and clutch levers are brought to a position near together, so that the whole is under control of one man.

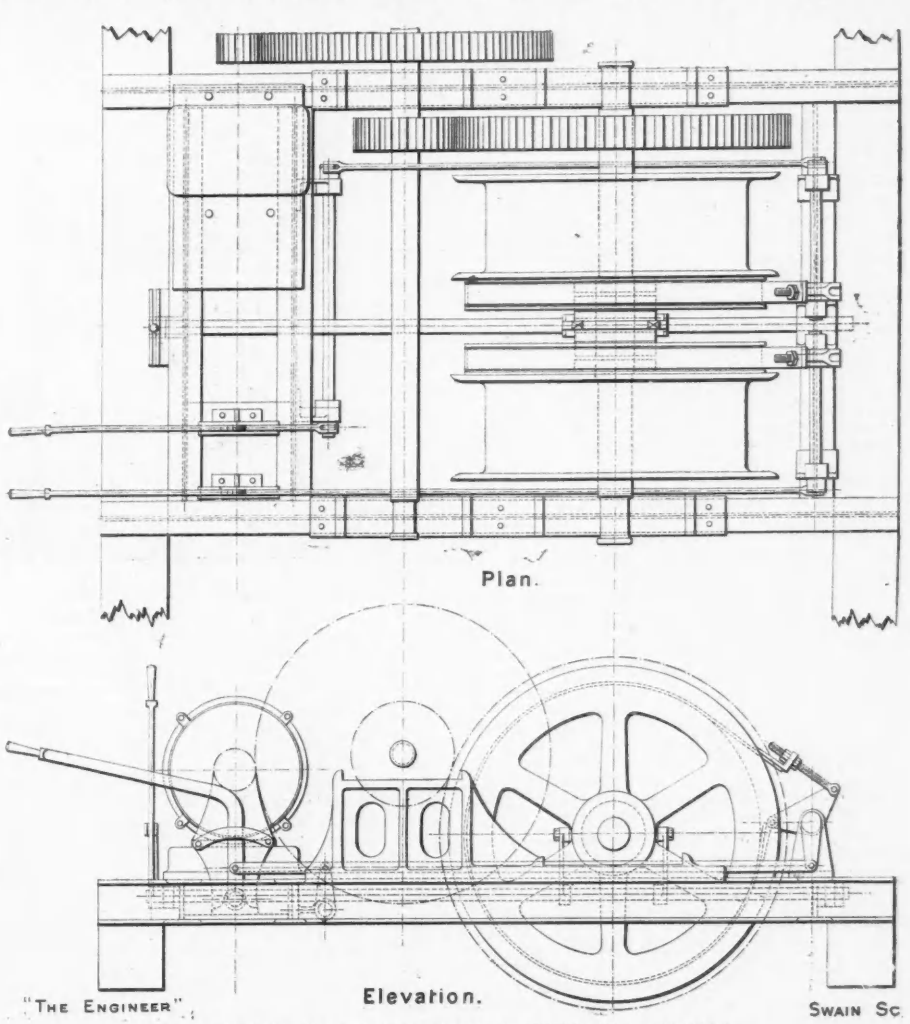


Fig. 46—MOTOR DRIVEN HAULAGE PLANT—ACKTON HALL COLLIERY

The screens are driven by an electric motor by means of a belt; the plant does not call for any special mention.

being dealt with in the same way as any other above-ground installation. The same remark applies to the coal-washing machinery, which is driven by two 80 horse-power motors. In both instances the work is well and easily done.

Regarding the various other applications of direct-current motors to work of different kinds, it is perhaps unnecessary to speak. It may, however, be of interest to repeat that they are employed for working a disintegrator; a saw mill; machinery in a brickyard belonging to the colliery; chaff cutting in the stables; machinery in the estate workshops and quarry; in the wagon, joiners', and mechanics' shops, in the latter of which some of the motors are coupled singly to larger sized machines; the

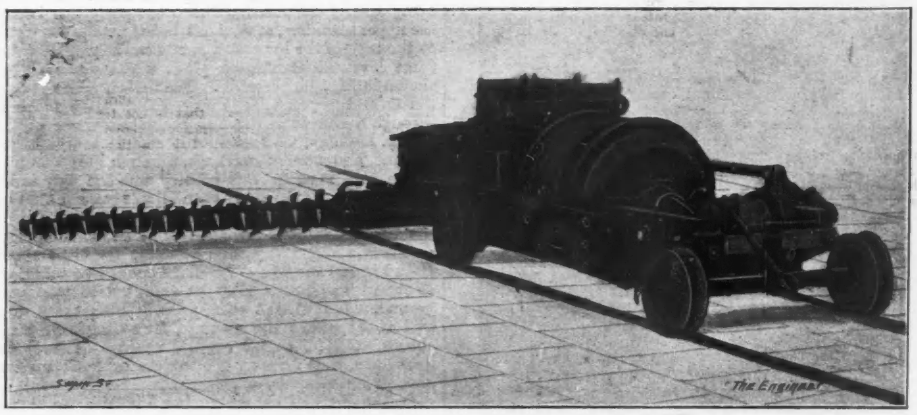


Fig. 47—COAL CUTTER AND THREE PHASE MOTOR

coke oven hoist; lamp cleaning machinery; fans and pumps. We must not forget to mention a point in connection with the coal washers. It is necessary to run these machines for considerable periods at about quarter speed to prevent the sludge from settling solid in the tanks. Mr. Holiday obtains this slow speed by the use of two motors, and by means of a switch which can couple the two motor in series and the fields in parallel.

We mentioned earlier on that three-phase motors were used for working the coal cutters. Mr. Holiday, who believes strongly in the use of three-phase current in coal cutting, was the first, in this country at all events, to apply successfully this method of driving to coal-cutting machinery, and we are enabled by his courtesy to give in Fig. 47, above, a reproduction from a photograph of a Hurd coal cutter, made by Messrs. Mavor and Coulson, and adapted for three-phase working by Mr. Holiday himself. In a communication which he made some little while ago to the Journal of the British Society of Mining Students, he gives some reason for adopting three-phase current for coal cutters, and details some of the experiences he met with before attaining success. In commencing the subject he draws attention to the fact that, with continuous coal cutters, the motors used are usually of the series type. In these, he explains, insulation is difficult because of the limited space, and maintenance is not easy because of the severe vibrations to which the motors are subjected, this vibration being one of the most frequent causes of breakdown. Rubbing contacts are also necessary with a consequent liability to sparking, this being due perhaps to mechanical, perhaps to electrical causes. He mentions the fact that makers do their utmost to minimise the dangers consequent on this. They design the motors in the first instance so that they give a minimum of sparking and then enclose them completely in cases which are called "gas tight." Inspection covers must, however, be provided, he continues, "and, as they must be left so that the men in the pit can open them, they are about as reliable as an unlocked safety lamp in the hands of miners."

In starting a series motor, he goes on, if the full current is switched on suddenly while the motor is at rest, a heavy rush of current passes through the armature, which lasts until the fuses blow or until it is switched off again. If this rush of current lasts long, the armature is burnt. Starting difficulties are overcome by means of resistances, but these are a constant source of trouble. Owing to varying temperatures and to the vibration, screws are liable to work loose and arcing to be set up. On the other hand, with continuous current only two cables are necessary.

Two-phase currents he passes over, saying that there are difficulties in starting. With three-phase currents three cables are required. The motors start fairly well. In these the full working current passes through the stationary part of the motors only; consequently there is more room for insulation, and breakdowns are much less frequent than with direct-current motors. The great disadvantage of the three-phase motor is that it has a very small starting torque—not nearly as great as that in a series continuous-current motor. In order to increase this starting torque resistances are introduced into the rotor circuit, and as a consequence there must be three slip rings to convey the current from the rotor to the resistances. These rings are of solid brass, and they are not liable to spark from electrical causes, but may do so if subjected to vibration. These were the considerations which confronted Mr. Holiday when he first set himself to work out the question of electrical coal cutting. He decided finally that if the three-phase motor could be given sufficient starting torque, it would be far safer and less complicated than the continuous-current motor. In his first experiments he used a Diamond Coal Cutter Company's cutter wheel and two 10 horse-power Brown Boveri motors. He, after some experiment, made the driving bevel wheel loose on its shaft, and close to it a disc which was firmly fixed to the shaft. On the rim of this disc was a projecting lug, and on the side of the bevel wheel was another projection, which just cleared the rim of the disc, but engaged with the projection upon it. Thus, the bevel wheel could make practically one revolution without driving the cutter wheel shaft, and hence without doing any work. The motors were geared 5 to 1, so that they could make five revolutions free. A reversing switch was also added, and with this arrangement it was found possible to liberate the cutter wheel, by letting the motors run forward, giving a jerk to it. This combination worked so well that the resistance rings were done away with, and the mo. started by being connected directly to the mains. This Mr. Holiday considers to be practically the secret of the application of three-phase motors to coal cutting. He has since adopted Hurd bar cutters, and has fitted each with a 20 horse-power three-phase motor. He has never had a fuse blow with a three-phase motor, though several times he has had disc machines pulled up dead. The reason for this is, as he explains, that the motors and the mains have a high induction which checks the flow of current. Hence he is able to place all his fuses on the surface—a great point. Mr. Holiday considers that the many advantages of three-phase plant quite counterbalance the extra cost in cable. He has found these motors work well, and has never had to change the bearings. He fits the motors to the cutters, and makes his own switch-boxes at the colliery. Indeed, this remark applies not only to coal cutters, but throughout the whole electric system. The coal cutter switches are closed with an accurately machined cover and cement

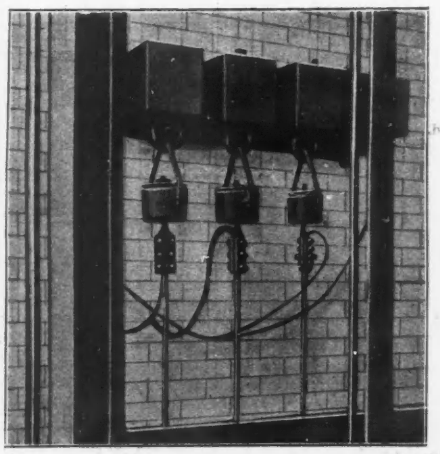


Fig. 48—CABLE SUSPENDERS

joint. The handle works into the box through a gland. He has never had any sparking. The voltage used is 320.

We noticed at this mine an ingenious contrivance, for suspending the cables going down the shaft, which has been patented by Mr. Holiday. Mr. Holiday prefers to use single cables for this purpose, and to have them of hard-drawn copper, with a light insulating covering. At the top of the shaft each cable is gripped in the clamp, and is held there by means of the six bolts and nuts. Thorough insulation is ensured by the construction of the suspender, which consists of an inverted cast iron basin provided with a hanger and with a central tube, up through which the stalk of the cable grip is passed. The bottom of the annular space formed in the cast iron basin by central tube is filled in with a ring of wood. Over this is placed a ring of rubber, and the remainder of the space is filled up with oil. The gripper stalk is passed through a hole in an inverted thimble, and secured by a cotter. The thimble is then dropped into the oil, and rests on the rubber. The whole is then closed in with a domed covering. Mr. Holiday informs us that he and others have found this arrangement answer admirably. The two engravings—Figs. 48 and 49, on this page—show this apparatus in section, and as it is arranged in actual practice. In this case the three cables were each 600 yards long. The engraving is reproduced from a photograph taken at the Ackton Hall Colliery. The suspenders are so arranged that the cables hang well clear of the side of the shaft, and when they reach the bottom they are given a slight bight before being looped up to the insulators, so that any moisture which may collect on and run down them will drip off at the bottom of the bight or loop, and not reach the insulators.

We cannot leave this mine without making mention of a three-phase pumping plant which has been installed. A reservoir has been constructed in a field belonging to the Colliery Company some 1000 yards away from the shafts. The water from a stream some 500 or 600 yards away is pumped into this reservoir by means of a centrifugal pump driven by two 10 horse-power motors coupled direct on to the shaft on either side of the pump. These motors have also been deprived of their slip rings, as have the coal cutter motors, and are started by being connected direct to the mains. An ingenious inductional contrivance, invented by Mr. Holiday, shows when the water level is getting too low, so that the attendant may know when to switch off the current without having to walk the 500 or 600 yards to see. The water from the reservoir is pumped to the pit mouth by means of a set of electrically-driven three-throw horizontal pumps, the motor in this case being of 15 horse-power three-phase. This is started by the aid of resistances, there not being sufficient "give" in the system to permit of their being done away with. Its ordinary working current with a voltage of 320

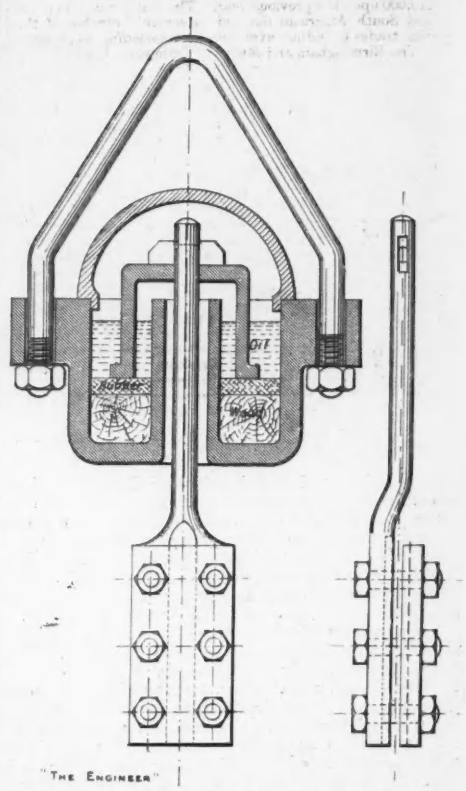


Fig. 49—THE HOLIDAY CABLE SUSPENDER

is about 44 ampères. If the current is switched right on without the resistances, the motor simply hums without moving, and a current of about 100 ampères passes.

THE BOLSOVER COLLIERY.

Another colliery which we were enabled, by the courtesy of its manager, Mr. Houlton, to visit was that belonging to the Bolsover Colliery Company. This pit is interesting in that, having some time ago adopted direct-current working for its haulage plants, it has recently installed a fairly large three-phase plant. The direct current plant at bank consists of a 100-kilowatt compound-wound four-pole dynamo, giving 600 volts at 720 revolutions per minute, this being belt-driven by a single-cylinder horizontal engine made by Messrs. John Davis and Son, of Derby, and a two-pole Goulden dynamo, giving 67 ampères and 528 volts at 630 revolutions. It is driven by a single-cylinder horizontal engine by means of an overhead countershaft and belting. There are, in addition, two lighting plants; one of these gives 200 ampères at 110 volts and 940 revolutions per minute, and the other 180 ampères at 110 volts at 805 revolutions per minute. Both of these are driven by horizontal Robey engines. The first-named generating plant drives a motor which is an exact counterpart of the dynamo as regards size, and this actuates a haulage gear by means of a belt. The second plant, until the installation of the three-phase dynamo, drove a series-wound motor near the bottom of the shaft, but at present this is not at work, though we understand it is shortly to be re-employed.

The three-phase installation consists of a 180-kilowatt Westinghouse generator running at 514 revolutions, and with a voltage of 440. It is driven by a vertical Westinghouse engine with two cylinders, each 20in. by 16in. stroke. The motor down the pit is of the Westinghouse make and of 200 horse-power, and works at 580 revolutions per minute, with a voltage of 400. It drives three endless rope haulages of 440 yards, 3600 yards—shortly to be made 4300 yards—and 2000 yards respectively. We were informed that the whole plant runs well and gives no trouble whatever. The switch gear is quite open, as there is no gas in the mine at this point.

WITH ELECTRICAL MINING MACHINERY SUPPLEMENT.

The Engineer.

Registered as a Newspaper

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VOL. XCVII.—No. 2530] LONDON: FRIDAY EVENING, JUNE 24, 1904. [PRICE {WITH SUPPLEMENT} SIXPENCE

Assistant Civil Engineers

in the Department of the Director of Engineering and Architectural Works in the Admiralty at the Head Office and the Outports (23-28).

An OPEN COMPETITIVE EXAMINATION will be held in JULY. Technical training and qualifications necessary.

Applications must be received at the Civil Service Commission, Burlington-gardens, London, W., not later than the 7th July, on printed forms to be obtained, with particulars, from the SECRETARY, Civil Service Commission, London, W. 1988

India-office, Whitehall,
22nd June, 1904.

The Secretary of State for

India in Council is prepared to receive TENDERS from such persons as may be willing to SUPPLY:—

SWITCHES and CROSSINGS for 75lb. rails, and SLIPS for ditto.

The conditions of contract may be obtained on application to the Director-General of Stores, India-office, Whitehall, S.W., and Tenders are to be delivered at that Office by Two o'clock p.m. on Tuesday, the 5th July, 1904, after which time no Tender will be received.

E. GRANT BURLS,
Director-General of Stores.
2056

PATENTS, DESIGNS, AND TRADE MARKS ACTS, 1883 to 1888.

Notice is Hereby Given that

HEINRICH KOPPERS, formerly of Carnap, near Essen, at present residing at 40, Rellinghauserstrasse, Essen, Germany, SEEKS LEAVE to AMEND the Specification of Letters Patent No. 25,278 of 1901, granted to him for "Improvements in Regenerative Coke Ovens with Separate Distribution of Gas and Air to the Heating Flues."

Particulars of the proposed Amendment were set forth in the Illustrated Official Journal (Patents), issued on the 15th June, 1904.

Any person, or persons, may give notice of opposition to the Amendment (on Form G) at the Patent-office, 25, Southampton-buildings, London, W.C., within one calendar month from the date of the said Journal.

C. N. DALTON,
Comptroller-General.
2002

Notice by the Stirling Company.

(The Original Manufacturers of the Stirling Boiler.)

53, DEANSGATE ARCADE, MANCHESTER.

The Stirling Boiler Company Limited of Edinburgh having ATTEMPTED to INTIMIDATE our customers by threatening them with legal proceedings for infringement, WE HEREBY INFORM PURCHASERS and USERS of our Stirling Boilers that WE WILL INDEMNIFY them against the consequences of any such legal proceedings for infringement, and FURTHER that we will, through our Solicitors, Messrs. Faithfull and Owen, London, DEFEND ANY SUCH ACTION.

Dated this 7th day of March, 1904.

For THE STIRLING COMPANY,
E. G. CONSTANTINE,
Manager, British Branch.
888

The Stirling Boiler.—Warning.

THE STIRLING COMPANY (who are the original makers of the STIRLING BOILER) HEREBY GIVE NOTICE that they have commenced proceedings for infringement of their Patent, No. 20,404 of the year 1895, against the Stirling Boiler Company, Limited, of Edinburgh, in respect of their Five Drum Boilers.

ALL PURCHASERS of such Five Drum Boilers from the Stirling Boiler Company, Limited, ARE HEREBY NOTIFIED that such proceedings have been commenced, and that USERS ARE LIABLE as well as Manufacturers, and that the Stirling Company intend to enforce their rights against all infringers.

Dated this 11th day of March, 1904.

For THE STIRLING COMPANY,
E. G. CONSTANTINE,
Manager, British Branch.
55, Deansgate-arcade,
Manchester. 983

The Glasgow and West of Scotland

TECHNICAL COLLEGE.
DEPARTMENT OF MECHANICS.

APPLICATIONS are INVITED for the following POSITIONS:—

Lecturer and Chief Assistant—Salary, £150 to £200.

Assistant Lecturer and Demonstrator—Salary, £100 to £125.

Candidates must have had workshop experience, and a sound training in mathematics and mechanics.

Further particulars may be obtained on application to Professor LONGBOTTOM, 36, Bath-street, Glasgow, to whom applications must be sent not later than July 13th, 1904. 1929

University of Birmingham.

CHAIR OF ELECTRICAL ENGINEERING.

The Council invites APPLICATIONS for a CHAIR of ELECTRICAL ENGINEERING.

The stipend offered is £1000 per annum, and the Professor will be at liberty to undertake a certain amount of consulting work.

The University will shortly be opening extensive buildings, with complete equipment for teaching the main branches of Engineering, Metallurgy, and Mining.

It is hoped ultimately to establish a Faculty dealing with Applied Science, and, outside teaching duties, there will be ample scope for powers of organisation and administration in helping to co-ordinate the work of such a Faculty.

In the Engineering Department there is already a Professor of Mechanical Engineering, and there are Lecturers on Civil, Mechanical, and Electrical Engineering, besides several Assistant Lecturers and Demonstrators.

The Council is anxious to secure a Professor who has had practical experience in his profession, and in the administration of work of some magnitude, and who at the same time is specially interested in the education of Engineers.

Further particulars may be obtained from the undersigned, to whom applications, accompanied by such evidence as to qualifications for the post as a candidate may think desirable, should be sent not later than the 1st August, 1904.

GEO. H. MORLEY,
Secretary.
1947

Bombay, Baroda, and Central

INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to noon on Thursday, the 30th instant, TENDERS for the SUPPLY of STEEL MATERIAL.

Tenders must be made on a form, copies of which, with specification, can be obtained at these Offices on payment of 2s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

T. W. WOOD,
Secretary.

Offices, Gloucester House,
Bishopsgate-street Without,
London, E.C.
21st June, 1904. 2029

County Borough of Halifax.—

The Tramways and Electricity Committee of the Halifax Corporation invite TENDERS for the PURCHASE of the following PLANT now out of use at their Electricity Works:—

One 50-KW. Single-phase Alternator, 83 cycles, 2200 volts.
Two 100-KW. " " " " " "
Two 120-KW. Direct-current Generators, 500 volts.

All the above are suitable for rope-driving, and were made by the Electric Construction Company, Ltd., Wolverhampton.

230 Single-phase Transformers, 2000 to 100-200 volts, by various makers.

One 8 H.P. Compound Robey Engine, with fly-wheel.

Full particulars may be obtained on application to Mr. W. M. Rogerson, A.M.I.E.E., Borough Electrical Engineer, Foundry-street, Halifax.

Tenders, endorsed "Disused Plant," must be sent to the undersigned on or before Monday, July 18th, 1904.

The Committee do not bind themselves to accept the highest any Tender.

By order,
KEIGHLEY WALTON,
Town Clerk.
996

Borough of Aston Manor.—

ELECTRIC SUPPLY DEPARTMENT.

The Corporation are prepared to receive TENDERS for the SUPPLY, DELIVERY, and ERECTION complete of:—

PIPEWORK, &c.

Specifications and forms of Tender may be obtained from Mr. T. J. Ballard, Corporation Electrical Engineer, Electricity Works, Chester-street, Aston Manor, on payment of £1, which will be returned on receipt of a bonâ fide Tender.

The lowest or any Tender not necessarily accepted; and firms tendering must not pay less than the standard rate of wages observed in their district.

Sealed Tenders, addressed to the Chairman of the Electricity Committee, Council House, Aston Manor, must be delivered on or before Twelve o'clock noon on Monday, July 18th, 1904.

Council House,
Aston Manor,
June, 1904. 2042

Bristol Docks. — New Dock

WORKS, AVONMOUTH.

The Docks Committee of the City and County of Bristol are prepared to receive TENDERS for the CONSTRUCTION, DELIVERY, ERECTING in place, FITTING, TESTING, and MAINTENANCE for twelve months of HYDRAULIC MACHINERY, consisting of Lock Gate Machines, Sluice Machines, Capstans, Swing Bridge Machinery, and Caisson Hauling Machinery, for the Royal Edward Dock, now in course of construction at Avonmouth, in the Port of Bristol.

Tenders will be considered only from firms who have done similar work before, and tenderers will be required to state what work they have done of a similar nature.

On and after the 20th day of June, 1904, copies of the specification, schedule of quantities, form of Tender, form of contract, and copies of contract drawings can be obtained from the undersigned on production of a receipt from the Secretary of the Docks Committee showing that £5 has been paid as deposit. The deposit of £5 will be returned to bonâ fide tenderers hereafter.

Tenders must be enclosed in a sealed envelope, endorsed "Tender for Hydraulic Machinery," and addressed to the Secretary of the Docks Committee, Docks Office, 19, Queen-square, Bristol, and must be delivered to him, accompanied by the necessary documents, before 10 a.m. on Monday, July 25th, 1904.

The Docks Committee of the Council of the City and County of Bristol do not bind themselves to accept the lowest or any Tender.

W. W. SQUIRE,
Engineer.

Engineer's Office,
Cumberland-road, Bristol,
June 14th, 1904. 1958

County Borough of Warrington.

LIGHT RAILWAYS.

The Corporation invite TENDERS for the SUPPLY, DELIVERY and ERECTION of STEEL POLES, TROLLEY WIRES, &c., forming complete overhead equipment for about 560 yards of double track, including special arrangements at the swing bridge over the Manchester Ship Canal.

Copies of specification, with form of Tender and general conditions, can be obtained at the offices of Messrs. Preece and Cardew, 8, Queen's Ann's-gate, Westminster, S.W., upon payment of a fee of one guinea, which will be returned on receipt of a bonâ fide Tender. Duplicate copies of the specification can be obtained on payment of 5s. (non-returnable).

The Contractor whose Tender is accepted will be required to observe the recognised customs and conditions as to rate of wages and working hours prevailing in the district.

Tenders, securely fastened and endorsed "Tender for Overhead Equipment," must be addressed to the undersigned, and delivered at the Town Hall, Warrington, on or before 12 o'clock noon on Tuesday, July 12th, 1904.

The Corporation do not bind themselves to accept the lowest or any Tender.

J. LYON WHITTLE,
Town Clerk.

Town Hall,
Warrington. 2025

Clyde Navigation.—To Crane

MAKERS AND ELECTRICAL ENGINEERS.
TWO ELECTRIC COALING HOISTS.

The Trustees of the Clyde Navigation invite TENDERS for TWO 32-ton ELECTRIC COALING HOISTS, for Clydebank Dock.

Copies of the general specification, with form of Tender, are to be had at this office from Mr. Geo. H. Baxter, the Mechanical Engineer, on payment of £3 3s., which will be refunded on receipt of a bonâ fide Tender.

Sealed Tenders, marked "Tender for Electric Coaling Hoists," to be lodged with the undersigned not later than noon of 25th July, 1904.

The Trustees may not accept the lowest or any Tender.

T. R. MACKENZIE,
General Manager and Secretary.

16, Robertson-street, Glasgow.
10th June, 1904. 1928

County of London.—To Con-

TRACTORS AND OTHERS.

The London County Council invites TENDERS for WORKS to be executed in connection with the RECONSTRUCTION of the BRIDGE carrying High-street, Kingsland, over the North London Railway near Dalston Junction, in the Borough of Hackney, in the Administrative County of London.

Persons desiring to submit Tenders may obtain the drawings, specifications, bills of quantities, form of Tender, and other particulars upon application to the Council's Chief Engineer, Mr. Maurice Fitzmaurice, C.M.G., at the County Hall, Spring-gardens, S.W., upon payment to the Cashier of the Council of the sum of £3.

This amount will, after the Council or its Committee shall have come to a decision upon the Tenders received, but not before, be returned to the tenderer, provided he shall have sent in a bonâ fide Tender and not have withdrawn the same.

Tenders must be upon the official forms, and the printed instructions contained therein must be strictly complied with.

The contractors will be bound by the contract to pay to all workmen (except a reasonable number of legally bound apprentices) employed by them wages at rates not less, and to observe hours of labour not greater, than the rates and hours set out in the Council's list, and such rates of wages and hours of labour will be inserted in and form part of the contract by way of schedule.

Each Tender is to be delivered at the County Hall, in a sealed cover, addressed to "The Clerk of the London County Council, Spring-gardens, S.W.," and marked "Tender for Reconstruction of Bridge carrying High-street, Kingsland, over North London Railway."

No Tender will be received after 10 a.m. on Tuesday, the 12th July, 1904.

Any Tender which does not comply with the printed instructions for Tender may be rejected.

The Council does not bind itself to accept the lowest or any Tender, and it will not accept the Tender of any person or firm who shall on any previous occasion have withdrawn a Tender after the same had been opened unless the reasons for the withdrawal were satisfactory to the Council.

G. L. GOMME,
Clerk of the London County Council.

County Hall, Spring-gardens, S.W.,
21st June, 1904. 2055

COMPOUND SURFACE-CONDENSING MARINE ENGINE, BOILER, &c.

The Cork Harbour Commis-

SIONERS invite TENDERS for a new COMPOUND SURFACE-CONDENSING MARINE ENGINE and BOILER for Hopper Barge No. 4. Also SAND PUMP DREDGING GEAR for the same vessel.

Specification and form of Tender can be obtained from James Price, Esq., M.I.C.E., Harbour Engineer's Office, 9 and 10, Lapp's Quay, Cork.

Tenders, marked "Tender for Engine and Boiler for Hopper No. 4," addressed to the Secretary, to be lodged with him before 5 p.m. on July 19th, 1904.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By order,
WILLIAM DONEGAN,
Secretary.

Cork Harbour Commissioners' Office,
9 and 10, Lapp's Quay, Cork,
15th June, 1904. 2012

Tenders are Required for Elec-

TRICAL INSTALLATION at the Cement Works of Messrs. Wm. Lee, Son and Co., Ltd., Halling, near Rochester.

To include Generator and the several Motors required, for which separate prices must be submitted.

Approximate I.H.P., 125.

For particulars apply to MANAGER, at the Works, where the different positions can be seen and further particulars obtained.

Messrs. Wm. Lee, Son and Co., Ltd., do not bind themselves to accept the lowest or any Tender. 2013

The Great Indian Peninsula

RAILWAY COMPANY.

The Directors are prepared to receive TENDERS for the SUPPLY of the following STORES, namely:—

Steel and Iron Work for Bridges.	Steel Fishing Pieces.
Cast Iron Sleepers, &c.	Coiled Keys.
Steel Fishbolts, Nuts, and Washers.	Copper Plates and Rods.
Tie Bars, Gibs, and Cotters.	Brass and Iron Screws and Split Pins.
Yorkshire Iron.	Open Hearth Acid Steel Loco. Boiler Plates.
Steel Rails.	

Specifications and forms of Tender may be obtained at this office on payment of the fee for the specification, which payment will not be returned.

Tenders must be delivered in sealed envelopes, addressed to the undersigned, marked "Tender for Steel and Iron Work for Bridges," or as the case may be, not later than 11 o'clock a.m. on Thursday, the 30th instant.

The Directors do not bind themselves to accept the lowest or any Tender.

J. I. BERRY, Secretary.

Company's Offices,
43, Copthall-avenue, E.C.,
London, 21st June, 1904. 2028

TO ENGINEERS AND OTHERS.

The Metropolitan Asylums Board

invite TENDERS for INSTALLING new BATHS and LAVATORY BASINS, with Services, in the Administration Block at Caterham Asylum, Caterham, Surrey, in accordance with plans and specification prepared by Mr. W. T. Hatch, M.I.C.E., M.I.M.E., Engineer-in-Chief.

Plans, specification, conditions of contract, and form of Tender may be inspected at the office of the Board, Embankment, London, E.C., on and after Friday, 24th June, 1904, and can then be obtained upon payment of a deposit of £2. The amount of the deposit will be returned only to persons who have sent in bonâ fide Tenders in accordance with the regulations.

Tenders, addressed as noted on the form, must be delivered at the office of the Board not later than 10 a.m. on Tuesday, 12th July, 1904.

(By order)
T. DUNCOMBE MANN,
Clerk to the Board.
20th June, 1904. 2017

The South Indian Railway

COMPANY, Limited, is prepared to receive TENDERS for the SUPPLY of—

ROLLING STOCK, comprising 20 Steel Covered Goods Wagons.

Specifications and forms of Tender may be obtained at the Company's Offices on and after Monday next, the 27th instant.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, and marked "Tender for Rolling Stock," must be left with the undersigned not later than Twelve o'clock noon of Tuesday, the 12th day of July, 1904.

The Company is not bound to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of the specification.

Copies of the drawings may be obtained at the office of Sir George B. Bruce, 3, Victoria-street, Westminster, on payment of 5s. per sheet.

By order,
HENRY W. NOTMAN,
Managing Director.

Company's Offices,
55, Gracechurch-street, London, E.C.,
22nd June, 1904. 2064

The Urban District Council of

HANDSWORTH.
ELECTRIC LIGHT AND POWER SUPPLY.

The Urban District Council of Handsworth invite TENDERS for the SUPPLY and DELIVERY of the following, in connection with the electric lighting:—

Contract No. 4—WATER-TUBE BOILERS.
" No. 5—ENGINES and DYNAMOS.
" No. 6—OVERHEAD HAND TRAVELLING CRANE.
" No. 7—STORAGE BATTERY.
" No. 8—ARC LAMPS and POSTS.
" No. 9—SWITCHBOARD and BOOSTERS.

Tenders will only be considered for the whole of the work covered by each specification and not for any part thereof.

Copies of the specifications, with the conditions of contract, &c., can be obtained on or after Saturday, 25th June, 1904, from the undersigned on payment of Three Guineas for each specification, which amount will be returned on receipt of a bonâ fide Tender, together with the specifications, drawings, conditions of contract, &c.

The specifications, conditions of contract and drawings can be seen at (but not obtained from) the offices of the Consulting Engineers, Messrs Kennedy and Jenkin, 17, Victoria-street, Westminster, London, S.W.

Tenders on the prescribed form, in sealed envelopes, and endorsed on the outside "Electric Light and Power Supply Tender, Contract No....," must be delivered at my office at the Council House, Handsworth, before noon on Monday, 11th July, 1904.

The Tender of any person or firm paying less than the standard rate of wages current in the district in which the work is executed will not be considered.

The Council do not bind themselves to accept the lowest or any Tender, and no allowance will be made for any expense incurred in the preparation of any Tender.

H. WARD, Clerk.

The Council House,
Handsworth, near Birmingham,
13th June, 1904. 2011

TROWBRIDGE SEWAGE DISPOSAL WORKS.
TO ENGINEERS.

The Urban District Council of

TROWBRIDGE invite TENDERS for the SUPPLY and ERECTION of GAS-PRODUCING PLANT, GAS ENGINES, and PUMPS for their Disposal Works at Trowbridge, Wilts.

Copies of the specifications and conditions may be obtained of the Engineer to the Council, Mr. W. H. Stanley, A. M. Inst. C.E., Market House-chambers, Trowbridge, on payment of a deposit of One Guinea, which will be returned on receipt of a bonâ fide Tender.

Sealed Tenders, endorsed "Tender for Machinery, Trowbridge Sewage Works," to be delivered or sent to me, the undersigned, on or before July 18th next.

Security will be required for the due performance of the contract.

The Council will not be bound to accept the lowest or any Tender.

By order,
T. S. HILL,
Clerk to the Council.

Town Hall, Trowbridge,
June, 1904. 1933

The Waterworks Committee of

Carrick-on-Shannon invite TENDERS for the SUPPLY and ERECTION of NEW PUMPING ENGINE and PUMP for the town supply. The engine may be a windmill or an oil engine or a steam engine with boiler.

The water is taken from the river Shannon, and is pumped up to a storage reservoir, distant about 800 yards, through a 3in. rising main. The total lift is about 85ft.

The supply required is four thousand gallons per hour, and contractors will be required to give a satisfactory guarantee that this rate of supply will be maintained for a period of five years after erection.

Tenders, which are to include carriage, erection, connections to rising main, shed accommodation, and all accessories of every kind, will be received by the SECRETARY, Waterworks Committee, Carrick-on-Shannon, up to the 11th July, 1904. P234

Executive Engineer Required for

the Public Works Department of the Federated Malay States.

The services of this officer are specially required for the construction of hydraulic works in connection with the lighting of Kuala Lumpor by electricity, principally comprising the construction of a water race some three miles long, but he may be called upon to perform other suitable duties in any of the Federated Malay States.

He must be a fully qualified civil engineer, with practical experience in hydraulic works, including pipe laying, construction of buildings and erection of machinery.

Candidates should not be less than 30 nor more than 40 years of age.

The engagement is a temporary one only, for a period of two years. Salary £420 per annum, which will, for purposes of local payment, be converted into dollars at a rate of exchange based upon the average Singapore Bank monthly rate.

He shall also be provided with free unfurnished quarters on the works and free medical advice and treatment, and receive an allowance for the keep of one horse or a bicycle, and shall be paid the usual field allowance when sleeping away from headquarters, in accordance with the General Orders which may be in force from time to time, but when residing in Kuala Lumpor or elsewhere he will be required to pay a reasonable rent for his quarters at a rate to be fixed by the Government.

Half-salary will be paid during the passage out.

Full salary will commence from date of arrival in Selangor.

Security to the extent of £100 will be required.

Free passage, first-class, out and home again on termination of engagement.

The candidate selected will be required to pass a strict medical examination and sign an agreement before appointment. Applications, by letter (no special form required), stating age, whether married or single, and giving full particulars of experience, accompanied by copies of testimonials (not originals), with names and addresses of references of whom inquiry can be made as to capabilities and character, will be received by the Crown Agents for the Colonies, Whitehall-gardens, London, S.W., up to 9th July.

The following reference should be quoted on the left-hand top corner of letter of application:—M/1909.

The Crown Agents possess no further information in regard to this appointment, and cannot undertake to answer inquiries. 2058

Sierra Leone Government Rail-

WAY.—OPEN LINES.

LOCOMOTIVE SUPERINTENDENT REQUIRED FOR SERVICE ON THE ABOVE RAILWAY.

Term of engagement, three years in the first instance.

Salary £550 per annum, rising by increments of £25 every eighteen months to £650 per annum, with free single quarters, or an allowance in lieu thereof. First-class passages out and home, and liberal leave allowance on full pay.

Candidates should be between 30 and 45 years of age, possess a thorough general and technical education and good organising and administrative ability. They must have been trained in the Shops of a Railway or Locomotive Builder, and have been engaged in an executive position in the Running Department of a Railway, and be thoroughly experienced in the Office Work of a Locomotive Department.

The selected candidate will be required to pass a strict medical examination, and to sail for the Colony at an early date.

Applications, giving full particulars of experience, age, names and addresses of references, and enclosing copies (not originals) of testimonials, to be addressed to Messrs. Shelford and Son, Consulting Engineers, 35a, Great George-street, Westminster, S.W.

Applications to be marked "Locomotive Superintendent." 2060

The Consett Iron Company,

Limited, will in November next REQUIRE the SERVICES of a SECRETARY and COMMERCIAL MANAGER.

Applications for the appointment, stating age, length, and character of experience in like positions, salary expected, and giving two or more references, to be addressed to Messrs. COOPER and GOODGER, 27, Grey-street, Newcastle-on-Tyne.

The envelope to be inscribed "Consett Application." 1957

Wanted, an Engineer to Take

Charge of a Drawing-office in connection with an Iron and Steel Works. In addition to supervising inside work he must have had experience in dealing with men and the carrying out of work in the shops; also a thorough acquaintance with all machinery employed about recovery ovens, blast furnaces, open-hearth furnaces, and rolling mills, together with electric power distribution, and the providing of spares. A level-headed man required with considerable practical experience; state wages.—Address, 1997, Engineer Office, 33, Norfolk-street, Strand, W.C. 1997

Works Manager. — Required,

energetic man, accustomed to the best class modern Locomotive Practice; preference will be given to one who has had control of men and who is conversant with piecework prices. A good salary with bonus, and 3 years' agreement will be given to the right man.—Apply, stating full particulars and salary expected, to ROBT. STEPHENSON and CO., Ltd., Darlington, endorsed "Works Manager." 1942

Vacancies under Public Autho-

RITIES:—Engineers (Electric, Gas, Water, Tramway, &c.), Surveyors, Draughtsmen, Clerks of Works, &c.—Write, PUBLIC APPOINTMENTS ASSOCIATION, 33a, Farringdon-st., E.C. P107

Wanted, a Draughtsman,

accustomed to Tramcar work.—Address, stating age, experience, and salary required to W. D. T., at Horncastle's, 51, Cheapside, London. 1863

Wanted, a Good Mechanical

DRAUGHTSMAN for London Engineering Works; state age, experience, and salary required.—Address, P286, Engineer Office, 33, Norfolk-street, Strand, W.C. P286

Wanted at Once, Draughtsman

accustomed to small detail work. One with electrical knowledge preferred. Must be accurate and neat. Salary £2 per week.—Reply, giving full particulars as to experience, and enclosing references, to P281, Engineer Office, 33, Norfolk-street, Strand, W.C. P281

Wanted, by a Firm of Construc-

TIONAL Engineers, a good DRAUGHTSMAN must be quick and accurate, and have had experience in Crushing, Elevating, and Conveying Machinery.—Address, stating age, experience, and salary required, to 2070, Engineer Office, 33, Norfolk-street, Strand, W.C. 2070

Wanted, Capable Young

DRAUGHTSMAN, with thorough knowledge of Machine Design; state technical qualifications and shop experience; salary according to ability.—Address, P253, Engineer Office, 33, Norfolk-street, Strand, W.C. P253

Wanted, Ship Draughtsman in

Engineer's City office, capable of designing launches, tugs, and light draught river steamers, experienced in tendering preferred.—Reply by letter only to A. R. BROWN, Billiter-square-buildings, E.C. 2048

Draughtsman. — A First-class

MAN WANTED.—Write, stating age, qualifications, and salary required, CAMBRIDGE SCIENTIFIC INSTRUMENT COMPANY, Limited, Cambridge. 1971

Draughtsman Wanted in the

drawing-office of a large engineering works in the Midlands; state age, previous experience, and salary expected.—Address, 2065, Engineer Office, 33, Norfolk-street, Strand, W.C. 2065

For continuation of Small Advertisements see pages II., III., IV., and LXXVI.

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Draughtsman.—Wanted, Young MECHANICAL DRAUGHTSMAN of good address for Works in Bombay. One who can take out strains and stresses, and preferably with general construction experience.—Address, P238, Engineer Office, 33, Norfolk-street, Strand, W.C. P238

Junior Draughtsman Required for London Firm; one having had experience with launch, side and stern wheel machinery; state salary required. —Address, 2046, Engineer Office, 33, Norfolk-street, Strand, W.C. 2046

Junior Draughtsman, with mechanical experience, WANTED IMMEDIATELY in a Signal Contractor's Office in London; state age, experience, and salary required.—Address, 2045, Engineer Office, 33, Norfolk-street, Strand, W.C. 2045

Wanted, a Foreman for High-class Bridge Shop in the Motherwell district, near Glasgow.—Send full particulars and terms to WHEATLEY KIRK, PRICE and CO., Albert-chambers, Albert-square, Manchester. 2040

Foreman for Brass Foundry, EXPERIENCED MEN WANTED for light Gun-metal, Aluminium and Brass work, accustomed to repetition work, piecework and moulding machines.—Address, 2000, Engineer Office, 33, Norfolk-street, Strand, W.C. 2000

Wanted at Once, First-class ESTIMATING CLERK, Electrical experience essential, knowledge of gas plants preferred.—State age, experience, and salary expected, to N. H. R., at Horncastle's, 61, Cheapside, E.C. 1998

Wanted, Junior Assistant for Estimating in Engineer's Office; must be able to calculate weights from drawings and used to pricing out; cost experience preferred.—Address, 2032, Engineer Office, 33, Norfolk-street, Strand, W.C. 2032

Head Clerk Wanted by a Firm of manufacturers employing 80 hands; good accountant, able to organise and control the work of the general office; West of England.—Address, P238, Engineer Office, 33, Norfolk-street, Strand, W.C. P238

Wanted, a Good Jobbing Moulder, to Take Entire Charge of small Foundry, doing about two tons per week. Must be capable of producing good, sound Castings, suitable for machining. State wages required.—Address, 2015, Engineer Office, 33, Norfolk-street, Strand, W.C. 2015

Wanted, Fitter (36 to 40); One accustomed to repairing engines, mills, and general machinery, in small Engineer's Shop 40 miles from London.—Address, stating age, reference, and wages required, to 2021, Engineer Office, 33, Norfolk-street, Strand, W.C. 2021

Wanted, in London, a First-class BLACKSMITH, accustomed to general forgings and angle iron work; wages 9½d. per hour.—Address, stating age, experience, and references, to P251, Engineer Office, 33, Norfolk-street, Strand, W.C. P251

Are You Underpaid? The Motor Industry is in urgent need of capable DRIVERS, MECHANICS, and IMPROVERS. Large wages obtained by suitable men. Full instructions (theoretical and practical) in the mechanism and driving of motor cars can only be obtain'd from THE MOTOR HOUSE, 366-368, EUSTON-ROAD, LONDON, N.W., who have the largest school, works, &c., in Great Britain. Always 50 cars for pupils to familiarise themselves with at the works. Pupils are carefully coached at moderate inclusive terms by professors of engineering, and certificates granted to proficient pupils are recognised by all owners of motor vehicles as well as by the trade.—For full particulars, call or write. 2008

A. M.I.C.E. (32) Desires Respon-SIBLE POSITION shortly; docks, harbours, piers, railways, general civil engineering.—Address, P269, Engineer Office, 33, Norfolk-street, Strand, W.C. P269

A Mechanical and Electrical ENGINEER (A.M.I.C.E., M.I. Mech. E.), with wide and varied experience in the management and control of works at home and abroad, is now OPEN to a similar ENGAGEMENT; well versed in office work, commercial routine, charge of staff, and accustomed to the management of men; highest references.—Address, 2053, Engineer Office, 33, Norfolk-street, Strand, W.C. 2053

Appointment with Civil Engi-NEER or Engineers REQUIRED by Advertiser, who has had some seven years' experience, including time at college, and would accept moderate salary.—Address, P201, Engineer Office, 33, Norfolk-street, Strand, W.C. P201

Contractor's Agent (C.E.) Seeks ENGAGEMENT; just completing important railway contract; large and varied experience with contractors, on waterworks, railways (tunnels), &c.; age 45; energetic, good references, &c.—Address, P266, Engineer Office, 33, Norfolk-street, Strand, W.C. P266

Electrical and Mechanical Engi-NEER (29) DESIRES ENGAGEMENT, practical and theoretical training, ten years' experience in the erection and maintenance of electrical power plant in central stations and mines at home and abroad; highest testimonials; accustomed to control of men.—Address, P217, Engineer Office, 33, Norfolk-street, Strand, W.C. P217

Electrical Engineering. — Two brothers, age 18, having completed a two years' course of daily instruction in electrical and mechanical engineering at the Polytechnic Institute, Regent-street, are anxious to OBTAIN EMPLOYMENT and thoroughly LEARN the BUSINESS of ELECTRICAL ENGINEERS. — Address, E. H. 963, Messrs. Deacon's, Leadenhall-street, E.C. 2057

Electricity.—Young German, Age 22, educated at university, WANTS SITUATION as ELECTRICAL ENGINEER, having already had 5 years' experience; highest references.—Address, WILLIAM ATKINS and CO., Limited, Reliance Steel Works, Sheffield. 2001

Engineer and Draughtsman Re-QUIRES POSITION ABROAD, technical experience derived from King's College.—Address, P240, Engineer Office, 33, Norfolk-street Strand, W.C. P240

Engineer, Mechanical (29), Open to ENGAGEMENT. Engines, pumps, and steam plant; good general knowledge; experienced draughtsman; able to introduce specialities.—Address, P245, Engineer Office, 33, Norfolk-street, Strand, W.C. P245

Engineer, Mech. (29), Seeks an APPOINTMENT in General Engineering Works; long first-class shop training, college 2 years, and some works management experience with firm doing highest class work; good draughtsman; excellent references.—Address, P192, Engineer Office, 33, Norfolk-street, Strand, W.C. P192

Engineer (26), 1st Class Hons. B.Sc., 8 years shops and D.O., English and American experience, some knowledge of electrical engineering, well up in steam turbines, will be at liberty in August, and SEEKS POST as MANAGER or ASSISTANT, or similar POSITION of TRUST.—Address, 2019, Engineer Office, 33, Norfolk-street, Strand, W.C. 2019

Engineer (32) Requires Re-en-GAGEMENT; 5 years' shops, mechanical, and civil experience in general work; estimates, specifications, surveying, and supervision; good draughtsman; excellent testimonials; speciality, waterworks.—Address, P263, Engineer Office, 33, Norfolk-street, Strand, W.C. P263

Gentleman, with Wide Practical experience and First-class Board of Trade Certificate, REQUIRES POSITION as ENGINEER to a Central Station or Refrigerating Plant. Age 39. Salary required not under £300 per annum, or payment by results.—Address, P262, Engineer Office, 33, Norfolk-street, Strand, W.C. P262

Manager (Works).—Advertiser (32) SEEKS BERTH, preferably Machine Tool, High-speed Engine, or similar work. Been through good machine tool shops. Four years foreman large machine shop (American plant); past three years works manager 800 hands. Machine design knowledge. Principals only.—Address, 2071, Engineer Office, 33, Norfolk-street, Strand, W.C. 2071

Engineer (25), Five Years' Ex-PERIENCE in marine shop, three years abroad, WANTS BERTH, preferably abroad or at sea.—Address, P265, Engineer Office, 33, Norfolk-street, Strand, W.C. P265

Mechanical Engineer, Well-EDUCATED, WANTS SITUATION as ERECTOR or to Take Charge of Machinery. Good general knowledge, including marine, electrical, and refrigerating. Would go abroad; age 36; 1st class B. of T. cert.—Address, P281, Engineer Office, 33, Norfolk-street, Strand, W.C. P281

Re-engagement Wanted at Once by Engineer with steam, hydraulic, and motor car and van experience.—Address, P283, Engineer Office, 33, Norfolk-street, Strand, W.C. P283

Thoroughly Hard-working Prac-TICAL ENGINEER, M.I.M.E., &c., is OPEN to a RESPONSIBLE POSITION; General Engineering, Mechanical or Civil; best references; wide experience; very moderate salary for London district.—Address, P252, Engineer Office, 33, Norfolk-street, Strand, W.C. P252

To Manufacturers.—Engineer or WORKS MANAGER (40) will be OPEN to TAKE UP an ENGAGEMENT in a few weeks; electric transmission, hydraulic, gas producers, and general engineering experience; a thorough knowledge of all building trades, including designing, taking off quantities; control of men twelve years; good references.—Address, P272, Engineer Office, 33, Norfolk-street, Strand, W.C. P272

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Young Gentleman just Passed through Civil and Mechanical Course of Engineering at Crystal Palace, having Honours Certificate, SEEKS POSITION. Excellent draughtsman; highest references; nominal salary.—Address, P254, Engineer Office, 33, Norfolk-street, Strand, W.C. P254

Experienced Draughtsman De-SIRES CHARGE of SMALL OFFICE where opportunity offers of assisting in the works management.—Address, P230, Engineer Office, 33, Norfolk-street, Strand, W.C. P230

Junior Draughtsman. — Young man (22), with seven years' shop and drawing-office experience, SEEKS EMPLOYMENT; would accept small salary in a good office. — REDFERN, 6, Goodman-street, Burton-on-Trent. P277

Junior Draughtsman (20) Desires ENGAGEMENT. Good experience of Machine Work; understands blue-printing, also some shop experience. Moderate salary.—Address, P255, Engineer Office, 33, Norfolk-street, Strand, W.C. P255

Machine Tool Draughtsman (25) SEEKS POST as DRAUGHTSMAN or ASSISTANT to WORKS MANAGER; 3 years with first-class continental firm; home or abroad.—Address, P250, Engineer Office, 33, Norfolk-street, Strand, W.C. P250

Mechanical Engineer (27) Seeks POSITION as DRAUGHTSMAN or ASSISTANT MANAGER; 11 years' varied workshop and drawing-office experience.—Address, P270, Engineer Office, 33, Norfolk-street, Strand, W.C. P270

Engineering. — Foreman or EXAMINER.—SITUATION WANTED as above; 6 years lining out; well up in drawings, setting, and checking finished work; age 29; good references.—Address, P287, Engineer Office, 33, Norfolk-street, Strand, W.C. P287

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Under Foreman Moulder Seeks RE-ENGAGEMENT, or could TAKE FULL CHARGE; varied experience in machine, tool, engine, and general casting, also modern methods and cupola practice; age 35; habits regular and temperate; good references; character bear full inquiry.—Address, P268, Engineer Office, 33, Norfolk-street, Strand, W.C. P268

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Forwarding Clerk, Thoroughly experienced, SEEKS ENGAGEMENT, age 32, excellent testimonials, well up in railway rates, &c., accustomed to the control of men and packing machinery for home and abroad.—Address, P235, Engineer Office, 33, Norfolk-street, Strand, W.C. P235

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Advertiser (31) Seeks Situation as TIME or STORE KEEPER, or any responsible settled position; 13 years' outside bridge erection with one firm.—GRANTHAM, 3, Benyon-street, Shrewsbury. P273

Engineer, Fitter and Turner, WANTS SITUATION; heavy or light work, or charge of machinery. Good workman; N.S. London district preferred.—Address, P256, Engineer Office, 33, Norfolk-street, Strand, W.C. P256

Patternmaker (General or Engine) WANTS SIT. in SMALL WORKS; would do drawing and setting out; 13 years' experience and good refs.; 2 years and 10 months last sit.—Address, H. B., 33, Hugo-street, Moston, Manchester. P267

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Young Man Seeks Employment in Mechanical Engineering Works as IMPROVER; good draughtsman; excellent references. — Address, P246, Engineer Office, 33, Norfolk-street, Strand, W.C. P246

Engineering Pupil.—A Firm of Engineers in the West of England have a VACANCY for a premium PUPIL.—Address, 1114, Engineer Office, 33, Norfolk-street, Strand, W.C. 1114

Engineering Pupil. — Firm (Government Contractors), employing 500 hands, have VACANCY; varied classes of work done, affording excellent opportunities; premium moderate.—Address, 4, Engineer Office, 33, Norfolk-street, Strand, W.C. 4

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Partnership.—Wanted, a thoroughly practical and energetic MAN to JOIN a Private Limited ENGINEERING COMPANY in the neighbourhood of London; should be able to introduce capital and supplement existing manufactures.—Address, 1673, Engineer Office, 33, Norfolk-street, Strand, W.C. 1673

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Wanted, a Steam Jib Travelling CRANE, to lift 4-5 tons.—Address, with price and particulars, 2044, Engineer Office, 33, Norfolk-street, Strand, W.C. 2044

Wanted, Fly-wheel, 9ft. Dia-METER, 8in. face, 7½in. or 7¾in. bore, weight about 50 cwt.—Address, COCKER BROS., Ltd., Sheffield. P239

Wanted, Good Lancashire Boiler 28ft long by 7ft. dia., must pass insurance 80 to 100 lb. pressure.—Price and full particulars to DAWSON, 74, Beckwith-road, Herne Hill, London. 2033

Wanted, Lathe Headstock, heavy, for experiment with broad massive bed; would purchase complete lathe if cheap.—Address, P280, Engineer Office, 33, Norfolk-street, Strand, W.C. P280

Wanted, One or Two 12 H.P. or late 14 H.P. single-cylinder Fowler PLOUGHING ENGINES, cheap for cash; condition of fire-box, tubes and boiler immaterial.—Address, 2031, Engineer Office, 33, Norfolk-street, Strand, W.C. 2031

Wanted, One 10½in. Centre SLIDING and SCREW-CUTTING LATHE, with Friction Head and Hollow Spindle; bed 14ft. long; a very powerful and most modern tool for high-speed cutting.—Particulars and lowest price to 2018, Engineer Office, 33, Norfolk-street, Strand, W.C. 2018

Wanted to Buy, Dumpy Levels, second-hand, not necessarily in good condition.—Address, C. M. G., care Davies and Co., Advertising Agents, 23, Finch-lane, Cornhill. 2066

Wanted, Two Second-hand PRIESTMAN GRABS, capable of lifting two tons and five tons of small coal; must be in thorough working condition; quote full particulars.—Address, 2016, Engineer Office, 33, Norfolk-street, Strand, W.C. 2016

Wanted, 6 or 8 H.P. Vertical or HORIZONTAL ENGINE by good maker, with automatic cut-off preferred.—BARTON and CO., Sudbury, Suffolk. 2067

Wanted, 200 I.H.P. Self-con-TAINED HORIZONTAL ENGINE, with outer bearing, spur gear preferred.—ENGINE, care Street and Co., 30, Cornhill, E.C. 1921

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For Sale, Cross Compound ENGINE, 13in. and 20in. by 24in., by Turner of Ipswich; HORIZONTAL ENGINE, 13in. and 24in., condensing.—A. UNDERWOOD, 3, Queen-street, E.C. 1920

For Sale, Direct-coupled Engine and DYNAMO, by Willans and Robinson; 115 volts, 30 amps., 450 revs.; shunt wound; new 1895; just from work; a bargain. — WILLIAMS and SONS, South Bermondsey Station, London. 2035

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For Sale, Double Geared Hori-ZONTAL BORING MACHINE, planed and T-slotted bed 12ft. by 2ft. 6in., three standards with cross slides, 2ft. 6in. self-acting feed, three speeds, nearly new.—THOMAS JOHNSON, Engineer, Wigan. 2051

For Sale, Dynamo, by Jackson and Co.; 110 volts, 370 amperes, 570 revs.; fitted with tachometer on sliding rail bed; a new spare armature.—WILLIAMS and SONS, South Bermondsey Station, London. 1840

For Sale, Electric Plant, Com-PLETE, consisting of two Water-tube Boilers, by Hornsby and Son, 150 lb. steam; combined set Compound Engine, 150 B.H.P., by Bellis and Morcom; Dynamo, 100 volts, 900 amps., 450 revs.; smaller, at 50 B.H.P., 105 volts, 340 amps., 575 revs.; Feed-water Heater, two Robey Feed Pumps, Switchboard, and Piping; together or separate. The whole plant equal new; not done four months' work.—A. UNDERWOOD, 3, Queen-street, E.C. 2065

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RADIAL DRILLING MACHINE, 3ft. 6in. radius.
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PLANING MACHINE, to plane 6ft. by 2ft. 6in. by 2ft. 6in.
„ „ 4ft. by 2ft. by 2ft.
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„ „ „ 9in. „ 10ft. „
„ „ „ 14in. „ 20ft. box end gap bed.
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Garrett and Sons, Ld
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Ruston, Proctor and Co., Ld
Turner, E. R. and F., Ld

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Le Grand and Sutcliff
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Asbestos Co., United, Ld
Witty and Wyatt, Ld

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Drum Engineering Co
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Bell's Asbestos Co., Ld

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Cochran and Co., Annan, Ld
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Spencer, W. H., and Co
Stirling Boiler Co., Ld
Stirling Co. of U.S.A.
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Humboldt Eng'g Works, Ld

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Fowler, J., and Co., Ld
Gimson and Co., Ld
Glamorgan Eng'g Co
Hall, J. F., and Sons, Ld
Hartnell, W., and Co., Ld
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Johnson and Phillips
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Laurence, Scott and Co., Ld
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London Emery Works Co
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Keith and Blackman Co., Ld
Marx, J., and Co
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Musgrave and Co., Ld
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Pitman, P.
Thwaites Brothers, Ld
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Caird and Rayner
Lancaster and Tonge, Ld
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Storey, I., and Sons
Wheeler Condenser & Eng. Co
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Phillips, J., and Co
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Hudson Economiser Co., Ld
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Fairbanks Company
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Tangyes Limited

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Brunton and Trier

Hammers:
Davis and Primrose
Fairbanks Company
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Samuelson and Co., Ld
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St. Helens Cable Co., Ld

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Gresham and Craven
Klinger, R., and Co
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Higgins and Co

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Severn, W. H.

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Hill and Smith
Lysaght, J., Ld
Main, A. and J., and Co
Morton, F., and Co., Ld
Piggott, T., and Co
Renshaw, W. R., and Co
Rowell, D., and Co
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Macfellan, P. and W., Ld

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Klinger, R., and Co
Dixon Crucible Co
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Hawthorn, Leslie and Co
Hunslet Engine Co., Ld
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Locomotive and Machine Company of Montreal, Ld
Lowca Engineering Co., Ld
North British Loco. Co., Ld
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Vulcan Locomotive Works

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Hulburd Engineering Co
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Stern Brothers
Trier Brothers
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Fielding and Platt, Ld
Gardner, L., and Sons
Glover, T., and Co., Ld
Hardy and Padmore, Ld
Hornsby and Sons, Ld
Pollock, Whyte and Waddel
Robey and Co., Ld
Samuelson and Co., Ld
Tangyes Limited

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Holden and Brooke, Ld

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